JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 25 JULY, 1933 No. 7

CONTENTS

All correspondence relating to the publication of papers should be addressed to the editor, Abel Wolman, 2411 North Charles Street, Baltimore, Maryland.

Because of the necessity for rigid economy, no reprints of articles will be furnished to contributors free of charge. Reprints may be purchased at the usual prices.

NATIONAL RECOVERY COMMITTEE FOR WATER WORKS CONSTRUCTION OF THE AMERICAN WATER WORKS ASSOCIATION

RESOLUTION STATING AIMS AND POLICY OF COMMITTEE

A RESOLUTION passed by the NATIONAL RECOVERY COMMITTEE FOR WATER WORKS CONSTRUCTION on June 28, 1933 and subsequently approved by letter ballot of the Board of Directors on July 7, 1933, is presented below. Its purpose is to make clear the policy and aims of the Committee for use in the guidance of those assisting in its work.

RESOLVED THAT

WHEREAS need for new construction and betterments of water works has accumulated during the past three years due to lack of funds, so that many water supplies proven to be inadequate in quantity or quality by droughts of 1930 and 1931 have remained unchanged and needed reinforcements, storage, pumps, meters, purification works, extensions and new facilities have been deferred thus reducing safeguards to health, convenience and property which normally would have been provided, and

WHEREAS the National Industrial Recovery Act (which has been called the "keystone of President Roosevelt's Recovery Plan") provides funds ample to allow communities to go forward immediately with all deferred and needed construction work and whereas such work is essential to revive capital investment, employment and purchasing power without which complete economic recovery is impossible, and

WHEREAS all needed funds may be obtained from the Federal Government by its political subdivisions, part as a direct grant up to thirty percent of the cost of labor and materials and the remainder as a loan at unusually low interest, to be repaid over an extended future period, and

WHEREAS certain private corporations in the public service including water companies can borrow from the Federal Government the funds required for needed construction at unusually low interest rates, and

WHEREAS material costs are low and need for employment is at a maximum in the field of production and installation of capital goods, and

WHEREAS all agencies have been requested by the Federal Administration to assist in creating jobs by initiating immediate construction of needed public facilities

NOW THEREFORE BE IT RESOLVED that the National Recovery Committee for Water Works Construction organize Section Recovery Committees in all local sections of the American Water Works Association to coöperate with the Federal Government and to

1. Aid local communities in presenting their projects and securing funds for construction of needed water facilities,
2. Assist local administrators, municipal, county, and state officials and other agencies, actively concerned in administering and receiving the benefits of the National Industrial Recovery Act,
3. Lend support to other types of needed public works construction, particularly in the field of sewerage and sewage treatment, as these are intimately related to proper water service and protection of sources of water supply,
4. Aim at the establishment of an improved standard of water supply and water service to conserve the public health, reduce loss of property by fire, and make available to a larger number of our people the conveniences resulting from adequate service of water of excellent quality.

NATIONAL RECOVERY COMMITTEE FOR WATER WORKS CONSTRUCTION OF THE AMERICAN WATER WORKS ASSOCIATION

RESOLUTION WHEREASES AND PURPOSE OF COMMITTEE

A RESOLUTION passed by the National Recovery Committee for Water Works Construction on June 26, 1933 and subsequently approved by letter ballot of the Board of Directors on July 7, 1933, is presented below. Its purpose is to make clear the policy and aims of the Committee in the discharge of its responsibility to the work.

RESOLUTION ADOPTED

WHEREAS since the first construction of water works in America there has [illegible] during the past three years due to lack of funds, so that many water supplies are now inadequate in quantity or quality to [illegible] and that long [illegible] and [illegible] pumps, treatment, purification plants, [illegible] have been deferred, [illegible] and [illegible] which normally would have been proceeding; and

WHEREAS the National Industrial Recovery Act has been called the "Keystone of Economic Recovery," [illegible] funds ample to allow communities to [illegible] with all deferred and needed construction work [illegible] such work is essential to restore [illegible] employment and purchasing power without which [illegible] economic recovery is impossible; and

WHEREAS all municipal [illegible] from the Federal Government [illegible] up to thirty per cent of the cost of labor and materials and the remainder as a loan at unusually low interest [illegible] over an extended future period; and

WHEREAS private corporations [illegible] including water companies can borrow from the Federal Government the funds required for needed construction at unusually low interest rates; and

WHEREAS material costs are low and need for employment [illegible] in the field of production and installation [illegible]; and

WHEREAS all agencies have been requested by the [illegible] to assist in [illegible] by initiating [illegible] needed public facilities.

NOW THEREFORE BE IT RESOLVED that the National Recovery Committee for Water Works Construction [illegible] Recovery Committees in all local sections of the American Water Works Association to cooperate with the Federal Government and to:

1. Aid local communities in preparing their projects and securing [illegible] of needed water facilities;
2. Assist local administrators, [illegible], and state [illegible] and other agencies, actively concerned in administering and receiving the benefits of the National Industrial Recovery Act;
3. Lend support to other types of needed public works construction, particularly in the field of sewerage and sewage treatment, as these are intimately related to proper water supply and protection of [illegible] water supplies;
4. Aim at the establishment of an improved standard of water supply and water service to conserve the public health, [illegible] of property [illegible] larger number of our people the conveniences resulting from adequate service of water of excellent quality.

JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

Vol. 25 JULY, 1933 No. 7

ELEVATED STORAGE AT LOUISVILLE

By Charles B. Burdick

(Of Alvord, Burdick and Howson, Engineers, Chicago, Ill.)

The improvements here described have the purpose of correcting the excessive hourly pumpage peaks through elevated storage. They have the effect of increasing the capacity of the pumps and distribution arteries about 50 percent. The pumps now run at nearly a uniform rate throughout the day and night.

The Louisville Water Company supplies the city of Louisville, Ky. and certain suburbs having a total population of about 330,000. The company is operated under an old State charter. All of the stock is owned by the city. The Water Department, therefore, has the advantages of municipal ownership as well as the advantages that come from a corporate organization. It is one of the earliest water works systems in the Middle West and has continued to enjoy a progressive management, early adopting the major improvements in water works service as they became useful from time to time. It is here that the earliest comprehensive studies were made upon mechanical filtration and it was one of the earliest plants to adopt filtration for the turbid waters of western streams.

The supply is pumped from the Ohio River to Crescent Hill, a distance of 2 miles, at a head of 190 feet. At Crescent Hill, the water is filtered and repumped into the general distribution system, until 1932 a direct pressure system, but now operated as a reservoir system.

About 2 percent of the water is again pumped to the high pressure suburban district lying east of Louisville served by two elevated tanks.

In common with the experience in other cities, the pumpage peaks have of late years become somewhat accentuated. This is probably due in part to better homes and grounds, and in part to more uniform hours of labor among all classes of the people through which the morning and evening demands come at much the same time from all classes of users. At Louisville, the total use in 24 hours upon a maximum day has changed but little in recent years, but the peak hour consumption upon such a day has shown a tendendy for increase more particularly in very hot and dry weather. The year 1930 was a record year in this regard for Louisville and other water works of the Middle West, and the experience during that drought emphasized the necessity for remedial measures, which had been under consideration for some time. This led to the construction of the elevated reservoir on Cardinal Hill immediately south of Louisville, including eight miles of 48- and 60-inch reinforced concrete pressure pipe, which form the subject of this paper.

PUMPAGES AND PRESSURES

The pumpage and population statistics covering the past decade are shown in table 1. Up to 1930, the greatest use in 24 hours had not exceeded 63 m.g.d., with 83 m.g.d. for the peak hour. In 1930, however, with the average annual pumpage not exceeding normal, the greatest use in 24 hours was 71 m.g.d. and the peak hour reached 116 m.g.d., a peak hour increase of over 40 percent. If good service is to be maintained, the peak hour demand must be met with resulting pressures satisfactory to consumers. During the peak hours of 1930 and in some other peak pumpage periods, the higher outlying consumers were unable to secure water through deficiencies in the distribution system, and the demands on the pumps at Crescent Hill reached the maximum safe delivery with one unit out of service. The remedy for this situation evidently lay between additional pumps and pipes and elevated storage for peak consumption water. Elevated storage was adopted after a comparative study involving relative costs.

In view of the reasonable availability of elevated ground convenient to the City upon the south, the opportunity was presented to store sufficient water to provide for future growth in demand peaks and also to store sufficient water for fire protection, thus relieving the

pumps and boilers from the responsibility of continuous operation, resulting in considerable increase in reliability of the station service.

TABLE 1

Pumpage statistics—Louisville Water Company

YEAR	POPULATION*	PUMPAGE M.G.D.			GALLONS PER CAPITA		
		Yearly average	Maximum 24 hrs.	Maximum hour	Yearly average	Maximum 24 hrs.	Maximum hour
1920	234,900	32.76	40.20		139	172	
1921	236,000	32.94	53.30		140	215	
1922	256,400	35.92	47.30		140	186	
1923	258,100	36.22	44.80		140	174	
1924	269,000	38.03	53.40	62.80	141	199	233
1925	300,000	41.06	63.01	82.96	137	210	276
1926	310,000	42.99	63.00		139	203	
1927	310,000	41.14	58.00		133	187	
1928	320,000	43.30	64.50	78.20	135	202	245
1929	330,000	41.99			127		
1930	330,000	41.12	71.1	116.00†	125	215	352
1931	330,000	36.88	62.0		112	188	
1932	330,000	38.18			115		

* Population includes suburban population furnished with water.

† Momentary peak rate in 1930 was 119.6 m.g.d.

HYDRAULIC GRADE LINES

The relative elevations at Louisville are shown in diagrammatic form in figure 1. The distance between the Crescent Hill Pumping Station and the Cardinal Hill Reservoir is about 14 miles, with the central business district of the city lying about midway between. The dotted lines indicate the pressure conditions under the direct pressure service previously existing. Under the conditions of a normal day with a demand of 60 m.g.d. or less, pressure conditions were very good even under 40 pounds at the Crescent Hill pumps. During the extreme peak hour in 1930, although the station pressure was increased to 50 pounds, little or no pressure remained in the outlying arteries, as indicated upon figure 1.

The reservoir has the effect of permitting the city to be fed from two opposite directions during the hours of peak consumption, thus greatly increasing the capacity of the pipes and reducing the pumpage

peaks. The full lines upon figure 1 show the estimated pressure conditions under reservoir service with a repetition of the 1930 drought in which the consumption of the maximum 24 hours reached 70 m.g.d. and the peak hour demand reached 116 m.g.d. with a 120

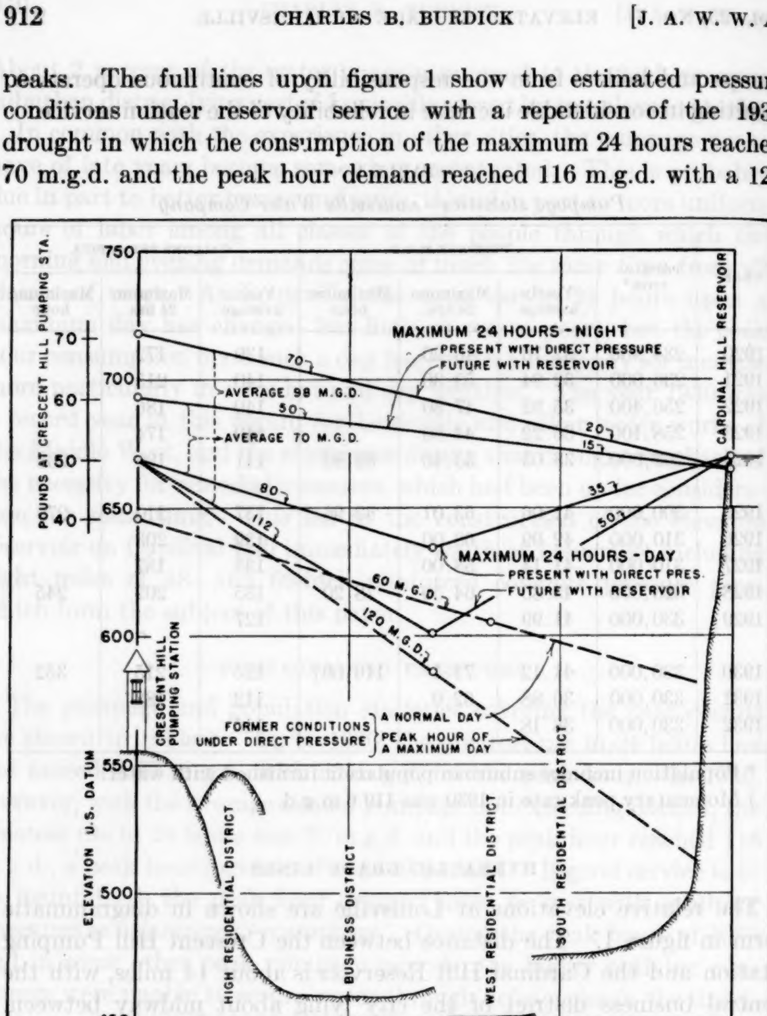


FIG. 1. TYPICAL HYDRAULIC GRADE LINES SHOWING EFFECT OF ELEVATED RESERVOIR—LOUISVILLE WATER CO.

m.g.d. momentary peak. Estimated conditions in the future are also shown in figure 1 with the present reservoir and pipes, under a total 24 hour use of 98 m.g.d., and assuming the rates of use by consumers to be proportional to the actual uses in 1930.

The reservoir was necessarily placed at sufficient height properly

to serve the city upon heavy pumpage days. When operating under direct pressure, it was customary to drop the Crescent Hill pressure to 40 pounds upon normal days and at night, increasing the pressure up to 50 pounds during the daytime when required. With the reservoir in service, the pressure at Crescent Hill varies from 50 to 60 pounds under present conditions. The annual average pumping head is about 25 percent more than formerly.

RESERVOIR

The Cardinal Hill reservoir is rectangular in plan, built of reinforced concrete with a flat bottom, vertical sides and flat top of column and slab construction, covered with one foot of earth. Depth of water is 20 feet.

The general principle of design embodies provision for stresses, treating the side walls as vertical beams restrained at top and bottom by the roof and the floor, so that the reservoir is self-contained, with or without the external pressure of the earth embankments. The design provides for the bending moments in the vertical side walls incident to rigid connections at the top and bottom, necessitating a liberal spread of the side wall footings at the bottom of the reservoir. Horizontal steel is provided for temperature in the amount of 0.4 percent of concrete cross-section. This ratio was varied slightly in roof and floor to provide for variations in temperature.

The common procedure of using copper sheet strips between day's pourings was followed. No other provision for expansion and contraction was provided, horizontal steel being tied completely through both reservoir compartments. The horizontal dimensions of the structure are 398 feet by 511 feet.

Special precautions were taken during construction to minimize expansion and contraction as much as possible by keeping all flat surfaces flooded immediately after pouring, and by keeping the walls wet by a system of spray piping inside and outside, until earth embankments were placed and the roof covered with earth. This did not prevent the appearance of numerous vertical hair cracks in the walls, most of them visible immediatly after stripping forms. Such cracks were anticipated and repairs provided for in the contract. This repair involved a machine cut $\frac{3}{4}$-inch wide on the face and $1\frac{1}{2}$ to 2 inches deep and calking with oakum and lead wool and finishing with cement mortar containing Irax water proofing. The total cost of crack repairs including labor and material, was about $450.00.

Upon completion, the reservoir was gradually filled during a period of several days. There was no ocular evidence of leakage. An eight day test with hook gage showed a water loss as follows:

First 24 hours	$\frac{3}{16}$ inch.
Second 24 hours	$\frac{1}{16}$ inch.
Next 6 days	$\frac{3}{16}$ inch total
Average leakage for final 6 days	0.031 vertical inch per 24 hours

The total cost of the reservoir complete, including control gates, gate house, roadways, sodding, remote valve control equipment, lighting and lawn sprinkling system, was $329,886.00.

PIPE LINES

The connection of the reservoir to the existing distribution system involved 20,171 feet of 60 inch pipe and 18,345 feet of 48 inch pipe, operating under heads up to about 100 pounds. Bids were taken upon Class C cast iron pipe and reinforced concrete cylinder pipe. Contracts were let to the Lock Joint Pipe Company for concrete pipe at a saving in cost of about 10 percent as compared to cast iron.

Conditions that influenced the selection of the reinforced concrete pipe under the conditions pertaining to this work, included the comparative reliability of steel and cast iron in restraining heavy pressures in large pipes and the probable advantage of concrete as a more permanent interior coating under the local conditions where serious tuberculation is found to occur in cast iron pipes.

Pipe joints are made from the interior of the pipes with lead gaskets calked as in laying ordinary cast iron pipe, with the excess joint space filled with cement mortar. Especial care was used in calking each joint. The mains were only filled once and no leaks developed.

Specifications required a leakage test under pressure with a measured leakage not exceeding 100 gallons per 24 hours per mile per inch of pipe diameter. Tests upon completion showed for the entire job, an average leakage of 27.8 gallons per inch mile day, or less than one-third of the specification allowance.

Nearly all of this work was done upon city streets, including a closely built residential district containing all usual public utilities. The lines were interconnected to the distribution system wherever subarteries were intersected and numerous blank tees were provided

to connect to future large pipes. A feature of the construction was the minimum of interference to traffic. Pipes were manufactured and cured in a convenient pipe yard and hauled to the job. Trenching and laying was done by Northwest trenchers. Specials were built in the pipe yard, hauled to the job and concreted after being placed in the ditch, thus completely filling the excavation without tamping. Adequate surfaces were provided to suitably back up all changes of alignment.

The total cost of the pipe lines including valves, air valves, valve pits, blow-offs and special foundation supports where contiguous to sewers, was $670,127.

Contracts for reservoir and pipe lines were let May 20, 1930. All construction work was completed before cold weather in December.

These improvements together with others all totalling $1,280,000, were financed with surplus earnings supplemented by short time local borrowings. The work was planned and supervised by the writer's firm, under the general direction of Mr. John Chambers, Chief Engineer and Superintendent of the Louisville Water Company.

(*Presented before the Illinois Section meeting, April 19, 1933.*)

MAINTAINING, READING AND BILLING OF WATER METERS IN BALTIMORE, MD.

By J. S. Strohmeyer

(*Distribution Engineer, Bureau of Water Supply, Baltimore, Md.*)

The Bureau of Water Supply is the successor of the Baltimore Water Company, a corporation organized in 1804 for supplying the City of Baltimore with water. The Company's property was purchased by the City in 1859, and from that time it has been operated by the municipality.

The report of the Water Board for 1869, shows that in March of that year, 29 water meters of the duplex piston type were installed, apparently the first meters following the municipalization of the plant. The growth of metered water supplies was slow, and it was not until 1918 that the Bureau had approximately 4300 metered services, which were all installed on industrial and commercial supplies.

Following the purchase of the former private water companies, the increase in the number of metered water supply services was rapid. They numbered 55,558 on January 1, 1933, located in Baltimore City and Anne Arundel and Baltimore Counties.

The reading and maintenance of water meters are done by the Bureau of Water Supply, and the billing and collecting of accounts by the Bureau of Receipts.

TEST AND REPAIR

The organization for the maintenance of these meters is centered at the Mt. Royal Maintenance Headquarters under an Assistant Maintenance Engineer, who reports directly to the Engineer of Maintenance. The personnel in the shop consists of a Junior Civil Engineer in charge; a Junior Clerk for keeping records and filing; a handyman for testing; a meter repairman, and three laborers. The laborers take the meters apart, clean the parts for the meter repairman, help on testing and do other miscellaneous shop work.

The meters are tested in the shop on three test benches. The $\frac{5}{8}$-,

$\frac{3}{4}$- and 1-inch meters are tested in series on No. 1 bench. The $1\frac{1}{2}$- and 2-inch disc and compound meters are tested singly on another bench, and the larger size meters, from 3- to 12-inch, are tested on the third bench.

The field force consists of two crews with trucks, and two handymen each with a Ford truck. Each crew consists of a meter repairman and a laborer. The repairmen make all the major repairs, and are supervised by the Junior Civil Engineer in charge of the repair shop. We have not found it economical to make field repairs on meters 2-inch or less in size. Such meters are removed and repaired in the shop; being replaced by a meter of similar size.

The handymen and truck are used on general work such as replacing broken registers and glasses, installing small meters, removing meters for a vacancy, delinquency, or replacing for repairs.

In making repairs to the larger size meters (3-inch or over), the part of the meter requiring replacement is furnished by the Repair Shop and is assembled in the field.

Water meters 2-inch or larger in size are read at two-week intervals and a close check kept on any falling off in registration as an indication of the need for repairs. The books containing these accounts are called large meter books and are closely scrutinized in the office of the Meter Division for such indications. It frequently happens that the decrease in registration indicates only a decrease in consumption.

The Junior Civil Engineer in charge of the meter shop has charge of these inspections, and by investigation or testing the meter determines if the decrease in registration is normal or caused by the failure of the meter.

The total maintenance expense of the Bureau from 1927 to 1931, inclusive, was about $2,294,000, of which $250,000 was for meter maintenance, representing about 11 percent of the total. As our cost records for meter maintenance include both the repairs to meters and meter vaults, the percentage of meter maintenance to the total maintenance expense cannot be ascertained. The expense of maintenance of meters and meter vaults was 4.3 percent of the total operating and maintenance expense of the Bureau from 1927 to 1931.

From our repair shop records, the annual average cost of repairs to $\frac{5}{8}$- and $\frac{3}{4}$-inch meters, representing 92 percent of the total number of meters in service, was 22 cents per meter in service. This repair cost is the average for the 6-year period, 1927 to 1932, inclusive.

Our records show that the cost of repairs to five $\frac{5}{8}$-inch meters in-

stalled 30 years ago has amounted to an average of 18 cents per meter per year. The combined registration of these meters was almost 750,000 cubic feet or an average cost of repairs per 1000 cubic feet registered of approximately \$0.035. Also, on five $\frac{3}{4}$-inch meters that have been in service for 32 years, the average cost of repairs amounted to 13.5 cents per meter per year.

READING

When an application is received for a water supply service it is sent to the Service Division for inspection as to the location of the service in the field; then to the Maintenance or Construction Divisions for the installation of the service and meter yoke. Generally the meter is not installed on $\frac{5}{8}$- or $\frac{3}{4}$-inch services until we are requested by the consumer. The installation can be made within 4 hours after receipt of notice. In some cases, however, the small meters are installed at the time of installation of the service.

After the water supply service and meter are installed, the application is forwarded to the Meter Division and the new account is opened. It is then given an account number and is routed in the meter readers' handbook. An authorization is sent to the Bureau of Receipts to make an addressograph plate on which the consumer's name, address and meter account number appear. The addressograph plate is then filed in its proper rack and is used quarterly for billing. From this same plate an impression is made on a handbook page, a ledger card and a file card, all three being forwarded to the Meter Division. The Meter Division notes on the handbook page and cards the size, kind and number of meter, the date of installation, the reading at installation and other sundry information which may help the reader to locate the meter on the premises. The account is then ready for reading and billing.

The meters are read quarterly by men who have passed a competitive meter reader's examination and are certified to the Bureau as Meter Readers by the City Service Commission. After their selection, the meter readers are given an intensive course of instruction in the meter repair shop so that they can recognize the different types of meters and registers and be able to discern defective or non-registering meters.

Each reader's equipment consists of a meter reader's hammer, flashlight, and a 1-inch paint brush which is used to clean the glass register cover. The meter books contain from 80 to 260 accounts, depending on the area covered. Each book represents one day's work.

The reader is required to record the statement of the meter, and make the extension on the handbook page. If the meter shows very little or no registration from the previous reading, the reader is required to ascertain whether or not the meter is registering, by requesting someone on the premises to turn on the cold water faucet and by observing the test hand on the meter. If the meter is not registering, a notation is made on the handbook page. The reader is instructed to report any unusual condition or defect that he may find in the meter, meter vault or meter cover, noting the condition on the handbook page.

As an aid to the meter reader, there is inserted in each book a list of conditions that are to be reported, each one opposite a number. There are 29 such conditions, and by noting the number on the page, it keeps the book neater and helps the reader. For instance, #1 means "meter not registering;" #6, "broken glass" and #27 "no one at home."

Upon completion of the book the reader is through for the day. The book is then brought into the office the following day and he receives another book for the current day. When the book is returned to the office it is referred to a clerk who checks the extensions on each account, and in cases where an abnormally high or low consumption is recorded, the reader not having fully ascertained any cause for this unusual consumption, a re-read sheet is made up by the clerk to be sent out and read by an inspector, who makes unusual efforts to locate the cause of the abnormal or subnormal consumption. The clerk also notes the defects reported by the reader and issues a work order on the Maintenance Division for the correction of the condition.

When the re-read sheets are returned they are entered in the handbook, and it is ready for billing. Before submitting the book to the Billing Department of the Bureau of Receipts, the readings and extensions on the handbook page are checked and copied on a ledger card which is a duplication of the handbook page. This card is filed, insuring the Meter Division of a duplicate record which can be referred to when access to the handbook is unavailable or, in the event the book is lost, it can be duplicated.

Upon the completion of the billing by the Bureau of Receipts the book is returned to the Meter Division where it remains until the next quarterly read.

The Meter Division keeps a card index of every meter account which is filed alphabetically by street names and numerically by

house numbers. On this card is an impression of the addressograph plate and the size, kind, and serial number of the meter. This card file is used to locate an account in the handbook.

The average number of daily meter reads per man is 144. Should the City become universally metered, this average would materially increase, and the cost per reading would be proportionately reduced.

A comparative statement showing the quarterly cost of reading a meter account for the years 1929 to 1932, inclusive is shown below. This cost includes expenses for salaries, transportation, and miscellaneous expenses appertaining to meter reading, but does not include overhead and office expense.

YEAR	NUMBER METERED SERVICES	DOLLARS	
		Quarterly reading cost per account	Decrease
1929	46,834	0.1071	
1930	50,728	0.1043	0.0028
1931	53,708	0.1041	0.0002
1932	55,558	0.1026	0.0015

This table shows that the cost has been decreasing each year. The cost of reading 17,464 meters during 1922 was $0.165 per quarter. Incidently the number of meters read daily per reader has increased from 93 in 1927 to 144 reads in 1932.

We consider this increase in daily readings the result of the large increase in the number of meters installed in meter vaults, the increasing number of metered services each year, and the re-routing of the meter accounts in the books.

BILLING

The cardboard form is 3½ by 18 inches. It is perforated in the center, forming two cards each 3½ by 9 inches. This form is passed through the addressograph machine, and after the consumer's name, address, and the account number are stamped on it three times, it is ready for the billing on two Underwood billing machines. The billing maching operators average about 350 bills daily per machine. These operators type on the form, which is folded on the perforation, the date of the meter reads, size of meter, extension, any delinquency, and total amount of bill. This information is duplicated by carbon paper.

The billing machine gives the total of the consumption and the

amount of revenue for each book so that the revenue can be checked. This revenue is compared with that of the previous quarter for statistical purposes. After the bill has been typewritten, the ledger stub, which is one-half of the form, is torn off and used as a customer's ledger, being filed in the Bureau of Receipts to correspond with the meter handbook and page. The other half, consisting of the consumer's bill and cashier's stub, is mailed to the customer. When making remittance, the consumer tears off the cashier's stub and mails it with his check, keeping the bill. If the remittance is made personally, the bill is receipted and returned to the customer, the cashier's stub being retained. The receipted cashier's stub is posted to the customer's ledger at the close of each day. Payment may be made at the Municipal Office Building or at the banks authorized to collect taxes.

The average time between the reading of the meter and the receipt of the bill by the customer is 10 days.

Five different colored bills are used, designating the respective rates applicable to consumers in Baltimore City, two rates in the Baltimore County Metropolitan District, Anne Arundel County, and a special rate for hydraulic elevators, charitable institutions, hospitals, etc.

Complaints are referred to the Meter Division, where they are noted on forms and forwarded to inspectors. Each complaint is investigated by reading the meter, noting the condition of the dial and glass, and observing whether there is any interior or exterior leakage. After these observations are made and the results recorded, the form is returned to the office and a letter written to the consumer apprizing him of the disposition of the case. If an error is made affecting the total of the bill, a Revision of Charges sheet is sent authorizing the Bureau of Receipts to make the correction and send the consumer an adjusted bill.

For the past half century the water meter has played a very important part in the constantly improving technique of water works operation. In the face of early indifference and adverse propaganda, the number of meters has increased continuously until the meter has become an almost indispensable servant of every community having a public water supply. The Meter Division has made substantial progress in the efficient handling of its meter accounts, and while we are aware that there is room for much more improvement, we feel we are working in the right direction.

(Presented before the 4-States Section meeting April 27, 1933.)

CROSS-CONNECTION AND PLUMBING-FIXTURE STUDIES

By Herbert L. White

(Sanitary Engineer, University of Illinois, Urbana, Ill.)

The possibility of re-contamination of the drinking water supply through a connection with a water supply that is not properly protected to insure a safe sanitary quality is well recognized by public health authorities. In a recent paper,[1] the statement is made that of the typhoid cases reported in the United States during the decade of 1920–29, caused by pollution of an apparently safe water supply, over 95 percent were due to unprotected cross-connections with polluted water supplies. Illinois has been entirely too prominent in these outbreaks of typhoid, because in a list of the twenty-five largest reported outbreaks of typhoid in the United States during the above decade, three of them were located in Illinois, and of the twenty-five largest reported outbreaks of dysentery, six of them were located in Illinois.

Most of us probably have thought of pollution of the water supply as a very remote possibility. However, if we remember that one unguarded cross connection in an Illinois city has caused two hundred cases of typhoid which resulted in twenty-four deaths, the cross connection will assume a much more important place in our minds.

Many of these cross connections are made or are used by persons who know such connections are dangerous, but who use the device as a matter of convenience. For instance, we have found that persons with training in sanitary engineering deliberately connected pipes containing drinking water directly to sewage pumps for use in priming the pumps.

The arguments in defense of cross connections are:

(1) The valve does not leak;

(2) The pressure on the drinking water supply is greater than the pressure on the non-potable supply, and if there is any leakage, water would flow *from* the drinking water pipe lines, rather than into them.

[1] Water-Borne Typhoid Fever Still a Menace, Abel Wolman and A. E. Gorman, Am. Jour. of Public Health, *21:* 2, 115.

In regard to the first point, one can never be certain when a valve will be opened by someone not familiar with the system or as a result of misinterpreted instructions. Furthermore, valves do leak. Anyone who has had experience in maintenance work is well aware of this fact. A short time ago, workmen at the University disconnected a pump from an 8-inch pipe. Although water in this pipe was under a pressure of only five pounds, it leaked past a check valve and a closed gate valve. In order to stop the flow of water completely, it was necessary to bolt a blind flange over the end of the pipe.

REDUCED PRESSURES ON SYSTEM

In regard to the second point, it should be pointed out that the water pressure at any particular building can be lowered or a partial vacuum can be created by any one of a number of things, as the fluctuating of the electric current that drives the motor-driven pumps at the pumping station, the closing of valves on pipes supplying water to the building, or by an unusually heavy demand for water either in the same building or in an adjacent building.

Probably to some of us the possibility of obtaining low water pressures in the distribution system seems rather far-fetched, but the frequency with which these occur will not be realized until continuous records of water pressure are made and studied. The frequency may be illustrated by citing data obtained at the University of Illinois. The pressure dropped, momentarily, three times during the year 1932, because of trouble at the pumping station. The causes were as follows:

(1) A short in the generator supplying current to drive the pumps;
(2) A fuse blown out on a transformer;
(3) A mistake in the operation of a valve.

During the first three months of 1933, two low pressures occurred. These were on the same day, when air accumulated in the suction of the high-lift pumps, after a change was made in the suction pipes.

Recently several very interesting papers[2] have been published

[2] W. C. Groeniger: Insurance Against Water-Borne Diseases Through Plumbing Fixtures, Plumbing and Heating Contractors' Trade Journal, September 1, 1927.

F. M. Dawson: Report on Investigation, Bulletin of Chicago Hospital Asso., *2:* 1 (November, 1930).

S. B. Morris: Cross Connections with Public Water Supplies, J. Amer. Water Wks. Assoc., *24:* 11, 1750.

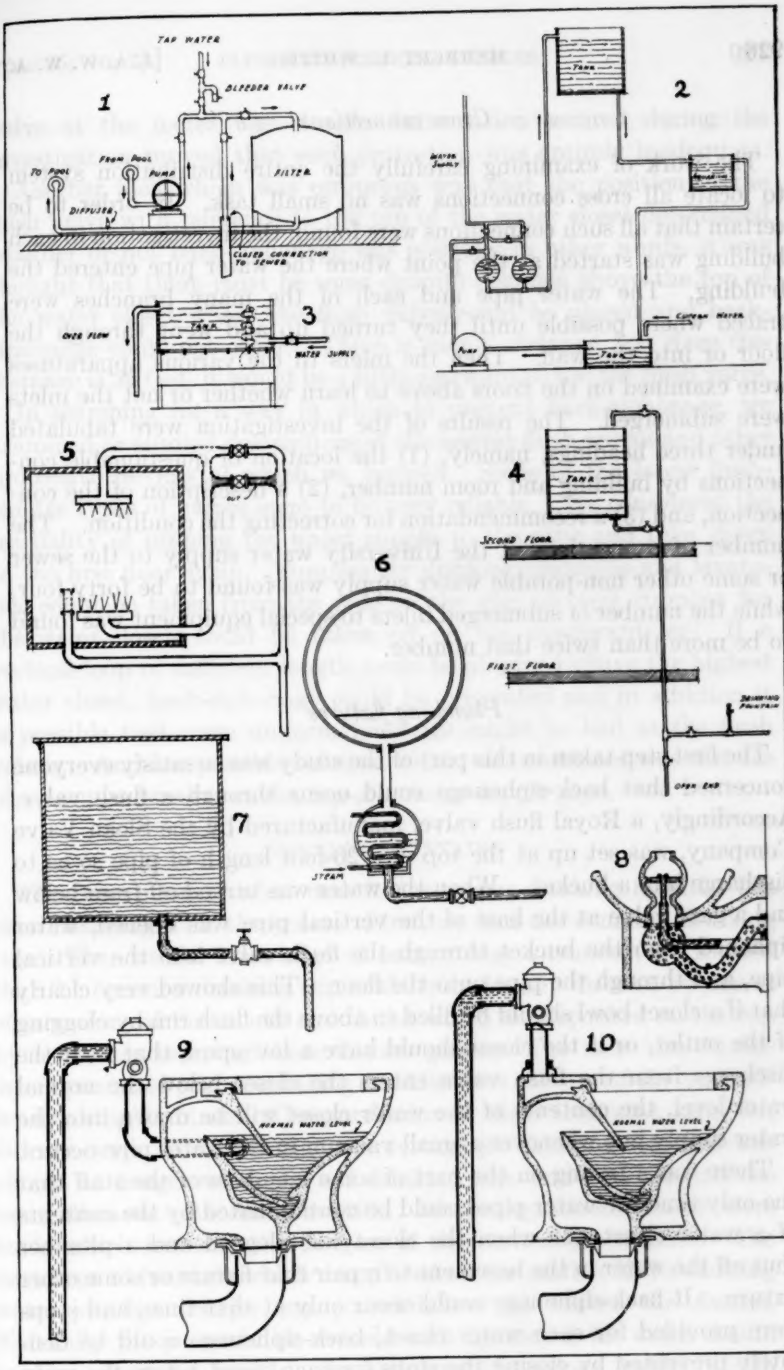
Joel I. Connolly: Private Cross Connections and Similar Menaces to Public Water Supply Quality, J. Amer. Water Wks. Assoc., *23:* 4, 495.

which discuss not only the dangers of the cross connection, but also the dangers of contamination of the water supply by siphonage of the contents of standard plumbing fixtures, such as water closets, sterilizers, lavatories, etc., back into the water pipes. These papers have related a considerable number of instances where the drinking water supply had been contaminated or could easily be contaminated in many ways that had not been considered previously.

INVESTIGATION AT UNIVERSITY OF ILLINOIS

Like many other water-supply systems, the water pipes at the University of Illinois have been allowed to be extended without careful consideration of the dangers of contamination of the drinking water through connection of the water pipes to the sanitary sewer and to various plumbing fixtures that might impair the safe sanitary quality of the water supply by back-siphonage. The State Department of Public Health realized the hazardous possibilities of the situation, and in the fall of 1931, recommended to the President of the University that a careful investigation be made of the entire water distribution system to learn what potentially dangerous connections or plumbing fixtures were in use. This recommendation was approved and the resulting studies are described in this paper.

For the purpose of simplifying the work, the study was divided into two parts. The first consisted of a survey of all water pipes and mains that were exposed, for the purpose of locating (1) all cross connections with non-potable supplies, and (2) all tanks or equipment from which the contents could siphon back into the drinking water lines. The second part consisted of a study of plumbing fixtures, such as water closets, bath tubs, lavatories, and drinking fountains.



1
TAP WATER
BLEEDER VALVE
FROM POOL
TO POOL
PUMP
FILTER
DIFFUSER
CLOSED CONNECTION TO SEWER
2
TANK
WATER SUPPLY
3
OVER FLOW
4
SECOND FLOOR
FIRST FLOOR
OPEN END
5
6
7
STEAM
8
9
NORMAL WATER LEVEL
10
NORMAL WATER LEVEL

FIGS. 1–10

Cross connections

The work of examining carefully the entire distribution system to locate all cross connections was no small task. In order to be certain that all such connections were found, the investigation in each building was started at the point where the water pipe entered the building. The water pipe and each of the many branches were traced where possible until they turned up and went through the floor or into the wall. Then the inlets to the various apparatuses were examined on the floors above to learn whether or not the inlets were submerged. The results of the investigation were tabulated under three headings, namely, (1) the location of questionable connections by building and room number, (2) a description of the connection, and (3) a recommendation for correcting the condition. The number of connections of the University water supply to the sewer or some other non-potable water supply was found to be forty-four, while the number of submerged inlets to special equipment was found to be more than twice that number.

Plumbing fixtures

The first step taken in this part of the study was to satisfy everyone concerned that back-siphonage could occur through a flush valve. Accordingly, a Royal flush valve, manufactured by the Sloan Valve Company, was set up at the top of a 20-foot length of pipe so as to discharge into a bucket. When the water was turned off from below and a gate valve at the base of the vertical pipe was opened, water siphoned from the bucket through the flush valve into the vertical pipe, and through the pipe onto the floor. This showed very clearly that if a closet bowl should be filled to above the flush rim by clogging of the outlet, or if the closet should have a low spud, that is, if the discharge from the flush valve enters the closet below the normal water level, the contents of the water closet will be drawn into the water supply line whenever a small vacuum in the water pipe occurs.

There was a feeling on the part of some members of the staff that the only time the water pipes could be contaminated by the contents of a water closet was when the closet was clogged and a plumber shut off the water in the basement to repair that fixture or some other fixture. If back-siphonage could occur only at that time, and stops were provided for each water closet, back-siphonage could be definitely prevented by closing the stops for each closet before the main

valve at the meter was closed. Information secured during the investigation proved that such protection was entirely inadequate.

Another idea which was erroneous was that the position of the flush valve with reference to the top of the water closet determined whether or not back-siphonage was possible; in other words, it was thought that there must be some definite distance above the top of the water closet where the flush valve could be placed and back-siphonage could not occur. There is such a distance, but since this distance is 34 feet, it would be a little awkward to use the flush valve.

In searching for a way in which to prevent back-siphonage, we examined or studied descriptions of the newest flush valves and other protective devices of which we learned. Some of the latest flushometer types of valves seem to be very reliable. We considered the feasibility of running the water supply to the attic and then down to the first floor again. Supplies for drinking fountains and lavatories could be taken from the pipe on the way up and supplies for the water closets could be taken off on the downward leg. If a vertical loop of sufficient length could be obtained above the highest water closet, back-siphonage could be prevented and in addition it is possible that more uniform pressures might be had at the flush valves. Another possible solution which we considered was the use of a vacuum breaker at the top of a water supply pipe.

DRINKING FOUNTAINS

The conception of what constitutes proper drinking facilities has been changing with the years. First, we had the common drinking cup. Then as the knowledge of bacteriology advanced, we learned that the common drinking cup could spread many diseases by means of secretions of the mouth and throat which are deposited on the cup by a drinker carrying these disease germs. The next step in the development of proper drinking facilities was the use of the vertical-jet drinking fountain. The purchasers of these fountains, however, did not seem to realize that the vertical-jet drinking fountain was almost as dangerous as the old drinking cup, and could spread the same diseases. As early as 1914, laboratory investigations were made which revealed the dangers of the vertical-jet bubbler. The next type of fountain which was placed on the market had a slanting water jet, but the jet was placed below the rim of the fixture. Naturally the jet could be covered with sputum if the drain should become clogged. Finally, the opinions of various public health

workers were crystallized in a joint report prepared by the American Public Health Association and the Conference of State Sanitary Engineers. The requirements for safe drinking fountains given in the above joint report were printed in 1931 in "Sanitary Drinking Facilities," Bulletin 87 of the Women's Bureau, United States Department of Labor.

We have found that the vertical-jet fountains may form a dangerous cross connection. The water supply pipe enters the fountain through the waste pipe, and if a leak develops in the water pipe, it will go unnoticed for a long time, since there is nothing except a slight noise to indicate that something is wrong.

DATA SHEET

The data sheet used in the study of plumbing fixtures was a mimeographed sheet having the following headings:

1. Fixtures:
   (a) Number.
   (b) Kind (water closet, lavatory, urinal, sink, drinking fountain, bath tub, shower bath).
   (c) Type (siphon jet, siphon, washout, approved, not approved).
2. Flushing device (high tank, low tank, Sloan flush valve, other flush valves).
3. Elevation of flushing device above top of closet.
4. Stops needed (water closets that do not have individual shut-off valves).
5. Low spuds (water closets in which the water enters at or below the normal water level).
6. Submerged inlets on lavatories (also includes bath tubs):
   (a) Number.
   (b) Amount in inches (distance inlet extends below top of fixture).
7. Room number.

The building and date were written in the upper right-hand corner of each sheet.

All plumbing fixtures located in the toilet rooms were tabulated on these sheets, and in addition, drinking fountains and lavatories with submerged inlets that were located outside of toilet rooms. After the survey was completed, the writer felt that it would have been better to have listed everything connected to the water pipes whether the individual fixture was hazardous or not. A complete list of fixtures and their location would serve many useful purposes.

Four water closets were found which were installed in such a way that the water supply was directly connected to the sewer. Three

of these were frost-proof closets, and the fourth was a closet equipped with a water-jet-operated vent.

CONCLUSIONS

1. The most hazardous condition in connection with a water closet is present when back or side spuds enter below the normal water line. Closets with this type of water inlet should be equipped with some positive device for the prevention of back-siphonage. The Sloan Crown valve with B. C. vacuum breaker and the Sloan siphon-preventor stop would be sufficient protection if the vacuum breaker can be located in the spud several inches above the rim of the fixture. The B. C. vacuum breaker has been replaced by the V-10-A vacuum breaker.

If it is desired to prevent back-siphonage from a large battery of closets already installed, it might be more economical to run the supply pipe upward in such a way that the water would pass over a loop at least 34 feet high. Thus the loop would break any siphon that could be formed, since even a perfect vacuum could not lift water that high.

A combination check valve and vacuum breaker placed in the tail piece of a flush valve might be used, but it would be wise to test it thoroughly before it is accepted. Some boards of health have approved this type of valve, but it is possible that such a valve might not work satisfactorily in a water high in bicarbonate.

2. Closets equipped with seat-acting flush tanks are about as hazardous as top-spud closets. These tanks should be replaced with a flushing device which will prevent back-siphonage.

3. Closets built for top spuds are not likely to back-siphon, unless the openings in the flushing rim are inadequate, either by design or by action of hard water because the possibility of the closet clogging, permitting the bowl to fill to above the flushing rim, and at the same time to have a drop in water pressure is not very great. The writer does not believe the hazard is great enough at the University to equip the closets with anti-siphon devices at the present time. Later, as repairs are necessary, replacements can be made.

4. The latest type of flush valves with siphon prevention accessories should be selected for making replacements for present flush valves, when such replacements are necessary. If only one make were to be selected, it would be much easier for the storeroom to carry extra parts for repairs.

5. Submerged inlets on lavatories and bath tubs should be raised, if possible, when plumbers are sent to do other work on such fixtures. In this manner, the fixtures can be corrected with little expense.

6. Water closets which are not equipped with individual shut-off valves should be so equipped. If the closet is served by a flush valve, the shut-off valve should be one of a siphon-preventor type.

(Presented before the Illinois Section meeting, April 20, 1933.)

THE REMOVAL OF ORGANIC BOUND IRON FROM HIGHLY COLORED WATER

By T. R. McCrea

(Formerly Superintendent of Filtration, Elizabeth City, N. C.)

The field of colored water ranging from 0 to 550 p.p.m. has been thoroughly covered by the works of many from Saville (1) to Enslow (2). The high color range from 550 to 1250 p.p.m., rare in nature, have had no mention, however, in scientific literature. It is in this high color range that this article attempts to present some information that may prove of value.

The heaviest color is in waters draining from swamps, and the intensity of such color is dependent on the swamp area, rainfall, temperature and the chemical composition of the swamp body itself. The color is attributed to dissolved substances of vegetable origin, extracted from the leaves, cypress roots, peat-muck and other vegetable components of organic disintegration. Glucosides, tannins and various derivatives thereof are supposed to be present in direct proportion to the amount of albuminoid nitrogen present and bearing a relation to the amount of carbon dioxide in solution. The exact nature of the coloring matter is unknown. However many proven features are evident as will be shown later.

THE GREAT DISMAL SWAMP

The Great Dismal Swamp is a tract of land 30 by 10 miles along the extreme eastern boundary of Virginia and North Carolina. In its center is Lake Drummond which is about 6 square miles in area. Elsewhere this peat-bog is covered with tangled weeds, timber and a thick undergrowth of stunted shrubs and dwarfed trees (3). The general terrain is swampy in character, often covered with a considerable thickness of decayed wood, swamp roots, peat and other naturally occurring humus matter, and saturated with water (3). During dry weather in certain sections this ground is known to catch fire, sometimes by spontaneous combustion, and burn for days.

The swamp as mapped in the Pasquotank area, with which we deal,

includes strips along the natural drainage ways that could not be classified as a soil type. It is subject to frequent overflow or is covered with water the greater part of the year. The surface material usually consists of peat, peaty muck, dark gray sandy loam, loam or silt loam and varies in depth from one or two inches to two feet or more. It is underlain by mottled yellow and gray, or yellowish sandy loam or sandy clay, or a drab clay with brownish or rusty iron streaks. The deep clay with rusty iron streaks is usually found along the natural drainage ways. The surface material along the small streams is generally more uniform and is a dark gray to gray silt loam, or silty clay loam. The grayish fine sand and sandy clay constitutes the usual subsoil in the peaty swamps near the larger streams, as along the Pasquotank river. These areas are at about sea level and water covers the surface from 6 inches to 5 feet deep throughout the year. In these low situations the surface is peaty or mucky and is composed of vegetable matter in all stages of decomposition, ranging in depth from 1 to 3 feet or more. Adjacent to the upland the surface soil is mixed with sand and fine sand.

The largest areas of swamp lie along the Pasquotank river, while a number of strips occur along many of the creeks. In places the swamp is used to a small extent for pasture. In many places it supports a heavy forest growth consisting chiefly of tupelo, cypress, maple and a few scattering pines, and the rest supports a dense undergrowth of all kinds of water loving plants and shrubs (4). Soundings as deep as 60 feet in some strictly swamp areas have disclosed the same peat formation with well preserved logs and other wood present (5). This swamp land is said to be the western extremity of the lost continent Atlantis (6).

This section of North Carolina and Virginia lies in close proximity to the sea. The Atlantic Ocean being about 20 miles to the east, Hampton Roads and the Elizabeth river to the north, Pasquotank river, Currituck and Albemarle Sounds to the south and southeast. The last three are generally fresh water under normal conditions. The Great Dismal Swamp of Pasquotank county is a tributary to Knobbs creek, Pasquotank river and Albemarle Sound in progression and in the order named.

WATER SUPPLY OF ELIZABETH CITY, N. C.

The months of May through August, 1930 afforded an unusual opportunity to study the water when it contained its highest possible

color. Extremely dry weather and high summer temperatures resulted in the very high concentration of color and organic properties. So acute was this drouth that the Pasquotank river and Knobbs creek, the source of the Elizabeth City, N. C. water, ceased to flow and the water remained in a stagnant condition for many weeks. This creek is the only source of supply to which the city has access. Many wells sunk prior to 1925 produced only brackish water. This city of 12,000 many years ago was a seaport of some consequence and vessels filled their tanks with this highly colored water because of its satisfactory keeping qualities. Natives, and many persons from distant points drank the raw clear water for its health giving properties, (the glucoside content having definite therapeutic value (8)).

About 1927 the city built a $235,000 filtration plant having a capacity of 2 m.g.d., supplanting the old antequated plant. From the time that this new plant was built to May 1930 the raw water supply was relatively low in color, varying between 150 and 550 p.p.m. The extreme drouth of 1930 brought about conditions which altered the situation and created the necessity of adjusting the treatment to handle the highest color ever dealt with. To understand the nature of the water better it is necessary to look into the chemistry of its production in nature.

ORGANIC DISINTEGRATION OF MATTER

Organic disintegration is continuous, beginning with green plant life and ending with an insoluble brown residue, (peat) water soluble substances, humins, humates and tannates which form the powder like properties of dried peat. Progressively we find the disintegration as follows, (1) chlorophyll stage, representing the green plant life; (2) wood fiber stage representing the fibrous woody materials; (3) mold stage bespeaks the biological effects on disintegration; (4) is represented by the first stages of peat formation wherein the water soluble substances enter into chemical reaction and proceed to the end product, peat.

In the first or chlorophyll stage we find alkaloids, pentoses, pentosans, hexoses, cellulose, chlorophyll, proteins, albumin and tannin substances (10). The proteins include the albuminoid nitrogen, the amino acids, and some humic acid and some humin substances, all of which are undergoing organic decomposition in the direction of the other stages. Cellulose is hydrolyzed to levulose which then gives levulinic carbohydrate which reacts with the mineral or amino acids

to produce hydroxymethylfurfurol which on further oxidation forms humin substances (9). Chlorophyll changes to starch. Albumin substances which are decomposed by biological action alone, proceed slowly in its decomposition reaction and consequently require a longer decomposition interval than lignin of the following group. Pentosans likewise undergo disintegration with a marked increase in the speed of the reaction. Due to the different rates of chemical and biological disintegrations many substances of one group appear in other groups, affording thereby no distinct line of demarcation.

In the second or wood fiber stage we find wood fiber undergoing decomposition by chemical and biological processes, the biological including the fungi principally. Lignin slowly reacts with the water soluble substance to form other compounds: Tannin and chlorophyll are reacting with substances in solution, independent of biological reaction, the rate of decomposition being considerably influenced by temperature and oxygen from the air. Proteins and starch, including the amino acids, do not form humins at low temperatures i.e. 8 to 10°C., but change readily at 37–38°C., water soluble substances playing a very active part in the formation of the humus.

In the third or more advanced stage we find humins, tannins and a slight bit of tannic acid, but principally the glucosides which when acted on by the biological ferments revert to the soluble glucose and gallic acid. The glucosides may be regarded as ethers or esters.

In the fourth or final stage we have humic acid, soluble salts of humic acid (humates), humus, humoid substances and some hydrogen sulphide. Further, the water of solution contains free and fixed carbon dioxide which presents added complication to chemical purification. Eller and Koch (11) show that the acid reaction of the humin substances is not due to adsorbed impurities. The humic acids are true acids, the acid reaction being due to the unchanged phenolic group. They are sometimes classed as creosotes. As a rule, most of the organic substances present hydrolyze slowly, causing variable results (12). Grosspopf (13) suggests that humic acid is derived almost wholely from lignin because of the destruction of cellulose by fungi and bacteria. Kurschner and Agnew (14) find that cellulose is largely hydrolyzed to glucose, later utilized by fungi. The lignin is more or less completely broken down, its carbohydrate parts are utilized, the aromatic portions remaining behind as a brown substance soluble in alkalies, known as humins, humic acid and humus. In the study of the chemistry of proteins Mann (15) proves

that the general formula for humin substances is roughly $C_{63}H_5O_{31}$. The high percentage of carbon and the low percentage of hydrogen is characteristic of the humin substances, whatever their source may be.

Waksmann (16) summarizes briefly the humin substances into two fractions designated as alpha and beta humins. The alpha fraction being readily soluble in dilute alkali and not precipitated by dilute acids. The beta fraction is soluble in dilute acids and dilute alkalies and is precipitated at a more or less definite iso-electric point which lies close to pH 4.8. In the purification of highly colored waters we deal with these two classifications solely.

TREATMENT OF HIGHLY COLORED WATER

In 1929 when the writer assumed charge of the water purification plant at Elizabeth City, N. C., the double coagulation process was being used. This process, which was not designed to combat organic iron, made use of chlorinated copperas $FeSO_4 \cdot 7H_2O$ plus chlorine at a pH of 4.2 to 4.7 as a primary treatment applied at the influent end of the mixing chamber, allowing a sufficient contact period for the formation of a noticeable flocculent precipitate. Secondary coagulation, consisting of alum and lime applied at the half way point and bringing the pH to 5.5 to 5.8, was capable of effecting a color reduction from a maximum of 550 in the raw water to about 10 p.p.m. in the finished water. This method afforded a decided advantage over any other method, or any other group of coagulants that had been studied up to that time (17) (18). This process, however, has shortcomings even in the lower range of color because the residual color of 7 to 10 p.p.m. in the filter effluent is later intensified about four times by the addition of any alkali with the possible exception of tri-sodium phosphate, which can be applied without producing a taste and causing a negligible color return. Color return is due to the alpha humins group which are not readily precipitated. Alpha humins remain in colorless solution until the water has been allowed to stand in the mains in the presence of metallic iron which apparently acts as a catalytic agent and causes precipitation, productive of a flimsy coating of a brown organic substance which is principally humates and ulmates. Further the negligible turbidity (18) in the raw water causes the floc to settle so slowly that the plant can operate only at a maximum of 75 percent of its capacity. Then again the settled floc in the coagulating basins has a tendency to disintegrate suddenly after standing from 7 to 21 days, giving up peptized iron, followed

by a combination of peptized iron and released color, necessitating immediate dumping of the entire content of the coagulation basin. Apparently the floc is not "fixed," that is sufficiently oxidized to render it stable.

The chief shortcoming of the ferric iron and alum-lime combination is its inability to cope with organic iron, which iron begins to appear in the raw water when the color increases to the higher color range, and its failure to destroy hydrogen sulphide in solution. In actual plant operation it was found that the soluble iron in the raw water passed undiminished through to the clear well and was often mistaken for the iron contributed through corrosion when tap samples were analyzed (19). The presence of iron was the cause of many taste complaints from consumers in the city. The taste was a characteristic swampy taste, unlike the iron taste due to corrosion or that of ferrous bicarbonate and similar compounds in solution.

The iron was present in the form of a soluble organic ferric iron, being a rather rare occurrence in nature. Its exact composition is not definitely known, but we do have a workable idea as to its nature. It is not susceptible to hydrolysis (20). Technical literature generally concedes that iron found in water of relatively high organic content is generally in combination with humic acid (21). The iron dealt with in our study as determined by the Standard Methods of Water Analysis (1930) was in the trivalent form. However, if this particular iron were in combination with humic acid it would hydrolyze to the hydrous ferric oxide within the pH range 4.2 to 6.2, wherein humic acid itself precipitates even though iron be bound to it (20). The failure to precipitate points to the fact that organic ferric iron in the Elizabeth City water is not humic acid bound and does not come under the beta humins classification, but rather under the alpha humins group. Hopkins (18) precipitates 2 p.p.m. of iron from a water having 300 p.p.m. color (with only a trace of iron in the filtrate) with chlorinated copperas and lime at a pH 3.5. Iron present in the water of higher color content does not precipitate, however, at such low pH values and should therefore be considered as other than humic acid bound.

In the Pasquotank area we earlier found that the sub soils of the peaty swamps along the Pasquotank river contain a deep clay enmeshed with brownish rusty iron streaks. Runchjelm (22) found iron in the body of leaves. Dennison (31) finds silica in the soluble sesqui-oxide state in soils. Vincent (32) finds soluble silicates de-

posited in the tissues of leaves, accounting probably for the silica content in the flocculent precipitate from chlorinated copperas by Hopkins (18). Brautlecht and Parlin (23) find iron in diminution in direct proportion to the extent of soil cultivation, and bearing a relation to the vegetation thereof. Halvorson (24) notes that small quantities of ferric iron appear in nature in mediums more alkaline than pH 5.0. Czapla (25) records that in the first stages of vegetable disintegration cellulose manifests a propensity for iron adsorption and Olsen (26) shows that throughout the four steps of vegetable oxidation humus itself adsorbs complex iron. However the most evident source of organic iron is shown by Smythe and Schmidt (27) wherein they find that the amount of iron in equilibrium with solutions containing certain proteins, amino acids and related compounds at various pH values enter their organic complexity through and by the polar effect in the molecule, particularly the hydroxyl group, alpha, and the carboxyl group of organic acids. Mann (15) also states that the humins in the presence of carbohydrates combine with ammonia and other nitrogenous substances thereby becoming nitrogenous themselves, in which state they take up iron and sulphur.

EXPERIMENTS TO CONTROL ALPHA HUMINS GROUP

During a period of many months a series of laboratory investigations were carried on, centering on the utilization of potassium permanganate to arrest and coagulate the alpha humins group. The summation of the laboratory results is as follows:

The analysis of the raw water studied in the laboratory indicated the characteristics in table 1.

Figure 1 deals with this water of low color and consequently represents figures, slightly different from the more favorable figures obtained during actual plant operation when treating water in the color range from 550 to 880 p.p.m. The plant filter effluent is negative is negative in iron content and in residual manganese. The alum content of the filter effluent is negative in the laboratory results and shows but slightly more than a trace in the plant filter effluent.

In the laboratory it was found that the minimum effective dose of potassium permanganate for this water was 0.25 grains per gallon. This quantity was sufficient to attack the alpha humins group, although did not come near satisfying the potassium permanganate demand exhibited by the water. After the color exceeded 600 p.p.m., 0.35 grains per gallon could be used to advantage. The dosage used

in the laboratory, therefore, is constant as there is no variation in the color of the water studied. The dose was: lime 20 p.p.m., chlorinated copperas 3 and alum 2 grains per gallon. The potassium permanganate was applied to the raw water as a primary dose along with the lime, and chlorinated copperas and alum followed.

The color in the raw water was not removed completely without the use of potassium permanganate, nor was the high iron content removed. The color was not removed by potassium permanganate and lime alone, nor with alum, lime and potassium permanganate, nor with permanganate and chlorinated copperas. The complete dosage, consisting of potassium permanganate, lime, chlorinated copperas and alum, is necessary for the complete color and iron removal from the Elizabeth City water when the color is in the high ranges. As the color moves up to 1260 p.p.m. the entire dosage can

TABLE 1

Analysis of raw water

(Results in p.p.m.)

pH	5.6
Alkalinity	18
Iron	2
Soap Hardness	30
Turbidity	8
Carbon Dioxide	20
Color	300

be moved up proportionately, that is, doubled in quantity. The dosage of lime, alum, and chlorinated copperas can also be kept at a constant figure and the permanganate moved to 0.50 grains per gallon.

To bear out one of our previous contentions that the disintegration is continuous until the humate-ulmate state is reached, we present an interesting fact relative to the behavior of the organic "rest" and organic bound iron which fact makes itself evident when the raw water is set aside free from contact with larger bodies of water and its muck-peat element or swamp body, and exposed to air. Apparently the process of organic disintegration of the swamp products is still continuing and after such process has ceased, the organic "rest" itself then undergoes oxidation and in so doing liberates the bound iron permitting it to go to the hydrous ferric oxide gel state and com-

pletely precipitate. The retention of the raw water is a primary factor. For instance, the sample containing color to the extent of 400 p.p.m. and an iron content of 2.0 p.p.m. is set aside in a glass

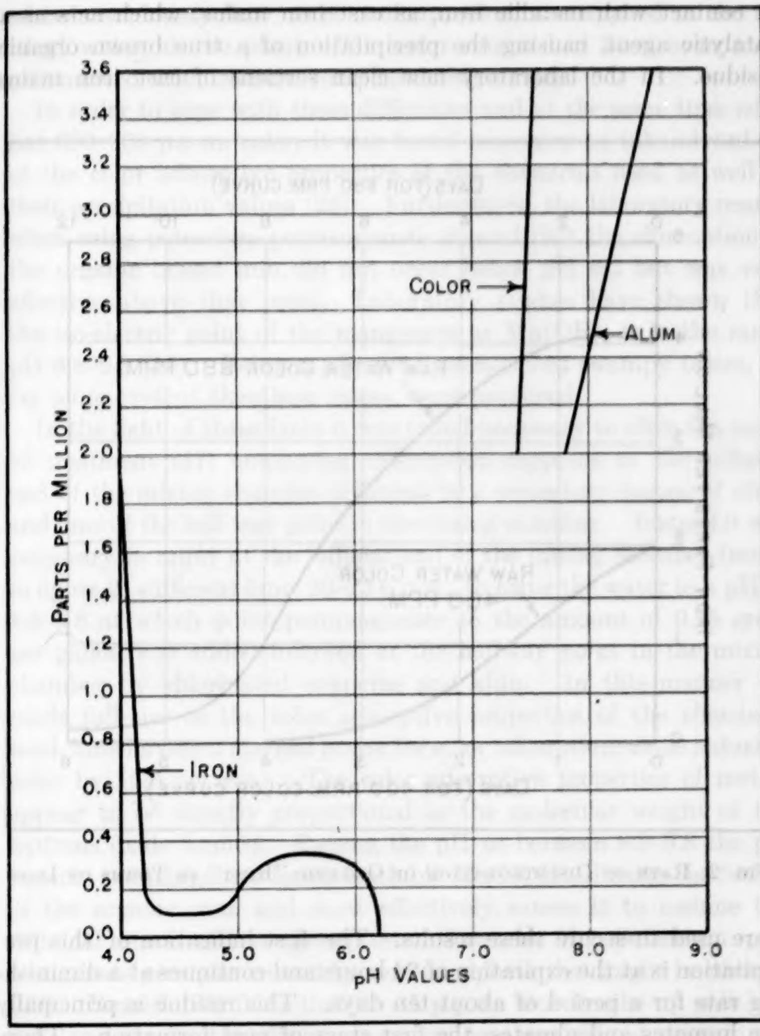


FIG. 1. BEHAVIOR OF LOW COLOR RANGE ORGANIC BOUND IRON IN PRESENCE OF POTASSIUM PERMANGANATE AT DIFFERENT pH VALUES, SHOWING RATE OF "FLOC" PEPTIZATION AT pH 7.4 IN TERMS OF ALUM AND COLOR

container. Using the iron content as an index of the oxidation, we find a decrease at the rate shown by figure 2.

The end products of the disintegration of the organic rest are at this point in complete solution and remain so indefinitely unless brought in contact with metallic iron, as cast iron mains, which acts as a catalytic agent, causing the precipitation of a true brown organic residue. In the laboratory new clean sections of cast iron mains

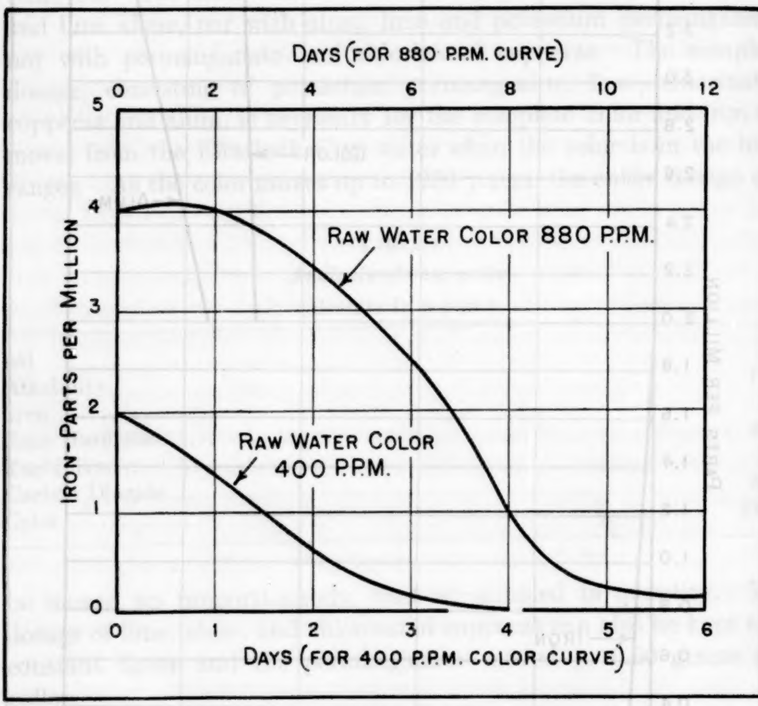


Fig. 2. Rate of Disintegration of Organic "Rest" in Terms of Iron

were used to secure these results. The first indication of this precipitation is at the expiration of 24 hours and continues at a diminishing rate for a period of about ten days. This residue is principally the humates and ulmates, the first stage of peat formation. These findings were first verified and reported to the N. C. State Board of Health under date of September 20, 1929. Subsequent examination of the city service mains revealed a flimsy coating, brownish in char-

acter, which when formed inhibits or rather retards further organic precipitation.

The application of potassium permanganate was directed at the alpha humins group which were responsible for the return of color when a secondary lime, to control corrosion, was applied to the finished water at the plant. The color return had been even more pronounced when sodium compounds were used.

In order to cope with these difficulties and at the same time combat 880–900 p.p.m. color, it was found necessary to take advantage of the color adsorptive properties of the chemicals used as well as their precipitation values (28). Furthermore, the laboratory results when using potassium permanganate showed that the elimination of the organic bound iron did not occur below pH 6.2 but was very effective above that point. Laboratory studies have shown that the iso-electric point of the manganese as $Mn(OH)_2$ is in the range pH 8.8–9.8 (18). Below a pH of 8.8 pronounced swampy tastes, by far more evident than iron tastes, were produced.

In the light of these facts it was found necessary to alter the mode of treatment (17) employing chlorinated copperas at the influent end of the mixing chamber, followed by a secondary dosage of alum and lime at the half way point in the mixing chamber. Instead it was necessary to apply at the influent end of the mixing chamber (see A in figure 2) sufficient lime, 20–22 p.p.m., to bring the water to a pH of 8.8–9.8 at which point permanganate to the amount of 0.25 grain per gallon was added followed at the halfway point in the mixing chamber by chlorinated copperas and alum. In this manner we made full use of the color adsorptive properties of the chemicals used, lime having a marked power for color adsorption, alone reducing color by 16.6 per cent. The color adsorptive properties of metals appear to be directly proportional to the molecular weight of the hydrous oxide formed. Raising the pH to between 8.8–9.8 the potassium permanganate forms insoluble $MnO(OH)_2$, breaks the "rest" of the organic iron, and most effectively causes it to assume the colloidal state and to precipitate. Likewise the potassium permanganate precipitates and hydrogen sulphide that might be present (29). Buzzell (30) finds that 25–35 p.p.m. lime breaks up colloidal color and excellent settling ensues, causing a marked reduction in the amount of alum required. Mom (31) finds that the alum effect in the precipitation of humic acid is brought about by the simultaneous influence of the H ions from the hydrolysis of $Al_2(SO_4)_3$ and the col-

loidal aluminum oxide. If and when tri-valent iron is used, H ions from the hydrolysis of the iron salt and the colloidal Fe_2O_3 likewise enter and help the precipitation.

Thus it can be seen that we are taking advantage of the precipitation value of potassium permanganate, ferric chloride, and aluminium sulphate (18) (28), the destructive color effect of hydrous calcium oxide on colloidal matter and the color and iron adsorptive properties of the hydrous oxides of calcium, iron, aluminium and the active oxy-hydrate of manganese, all of which serve to produce a very desirable

TABLE 2

Cost of treatment in dollars per million gallons

MONTH	MILLIONS OF GALLONS TREATED	IRON SUL-PHATE	LIME	ALUM	CHLO-RINE	CHEMI-CALS PER MILLION GALLONS	AVERAGE COLOR, PARTS PER MILLION
January	33.966	160	60.75	100.3	101.25	12.42	300
February	32.428	136	55.87	138.0	108.00	13.50	300
March	34.370	150	63.75	165.0	81.00	13.37	325
April	33.520	161	63.75	174.0	108.00	15.10	500
May	35.285	148	56.25	156.0	87.50	12.68	310
June	32.325	102	39.38	156.0	74.25	11.40	245
July	35.115	120	45.75	150.0	87.75	11.40	300
August	36.475	148	58.88	171.0	114.00	13.45	400
September	35.900	148	50.62	159.0	114.75	13.15	350
October	33.480	131	66.37	168.0	101.25	13.90	300
November	32.480	128	65.25	147.0	94.50	13.35	240
December	35.930	136	66.00	129.0	94.50	11.85	225
Average	34.272	139	57.71	151.8	97.25	12.97	320

iron free filter effluent to which alkalies, principally lime and caustic soda can be added with no subsequent return of color even though the pH be increased to pH 7.2–7.4. In the finished water there is a marked reduction of soluble ulmates and humates which previously have been shown to settle out in the presence of metallic iron.

The actual plant scale results from this treatment were practically as indicated by those in the laboratory. The laboratory work was done on 400 p.p.m. colored water and the plant scale operation was on water containing more color.

When potassium permanganate is used the cost is roughly two

dollars per million gallons, additional. The permanganate used was supplied by The Carus Chemical Company of La Salle, Ill., and is an American product.

ADVANTAGES OF PERMANGANATE TREATMENT

By the use of the additional potassium permanganate in the high pH range, many difficulties of plant operation and many disadvantages in control of the filter effluent were overcome. There was no return of color when secondary alkali was applied to raise the pH from 5.6 to 7.2. A comparatively rapidly settling flocculent precipitate was produced which permitted the plant to operate efficiently at a 90 to 95 percent maximum capacity. In a test run for several hours a full 100 percent capacity rate was reached with no disturbing effect on the coagulation basins.

With this treatment the coagulated material in the settling basins showed very little or no tendency to disintegrate, or peptize. At times when the color in the raw water was at 600 p.p.m., the settling basins were clear enough for the settled floc to be seen through a depth of 12 to 15 feet. The agglomerated floc was apparently "fixed" or properly oxidized and the effluent water was delivered to the filters containing a negligible quantity of iron, a negligible color and no manganese content.

During the months of July, August and September, 1931, favorable results were secured with potassium permanganate, although the details of the operation during this period are somewhat lacking. In a communication to the writer, Mr. Luther, now Superintendent of the Elizabeth City plant, states that "The maximum rate of water treatment was 1,800,000 gallons per day. Dosage 4.75 grains (per million gallons) chlorinated copperas, at peak of color. Caustic coagulant not figured as to dose, but in cost per million gallons. Would estimate approximately one grain per gallon. Prechlorination up to 20 p.p.m. At times lime added with the chlorine, dose of lime being 17.1 p.p.m. or less. This treatment, lime and chlorine was very good in removing iron. Potassium permanganate up to 0.25 p.p.m. was used. I found that 1.0 p.p.m. removed 0.5 p.p.m. iron." Further results are shown in table 3.

"Iron disappeared the first part of October. Highest color of the year was the first part of July, reaching 800 parts per million. No tests for iron at this time."

We gather from the above that Elizabeth City was successful in

removing organic bound iron with relatively high lime content and a prechlorination dose up to 20 p.p.m. It is stated (17) that prechlorination to the amount of 10 p.p.m. and higher bleaches color effectively.

Mom (20) states that neither chlorine nor hydrogen peroxide have the specific action, viz., a dispersing action on the hydrous ferric oxide that is possessed by potassium permanganate. He also states that if, in the process, free chlorine is present as in prechlorination, a part of the organic matter is held from coagulation by the destructive effect of the chlorine upon the humus colloids. It would be right to assume, therefore, that this soluble humus matter is at least in part

TABLE 3

Results of treatment, in p.p.m.

COLOR	IRON	
Raw	Raw	Finished
400	7.14	0.4
500	2.75	1.0
460	5.00	0.5
740	2.3	0.5
400	1.5	0.2
460	1.8	0.2
440	18.0	1.0
460	25.0	1.0
480	5.0	0.75
400	18.0	0.75
480	15.0	0.75
500	5.0	1.0

responsible for the residual color that appears in the filter effluent when heavy prechlorination is used in the place of the dose of potassium permanganate.

At Elizabeth City it has been found that in the lower color ranges under 500 p.p.m. in which organic iron in this water diminishes to a negligible quantity, alum and lime may be replaced by caustic soda and aluminium hydrate (mixed) applied at the mid point of the mixing chamber, following a primary dose of chlorinated copperas. This method is reasonably acceptable in the iron free low color range, but inadequate where high color and organic bound iron of the alpha humins group are prime factors.

SUMMARY

In technical literature we find that the use of potassium permanganate in the elimination of iron from water is recommended in those cases in which the iron is bound to organic substances with which it forms a stable compound which is not susceptible to hydrolysis. Hydrous ferric oxide which under certain circumstances flocculates easily is, therefore, not formed in these solutions during aeration and the iron remains in the finished water, bound to the colloidal color. In this case potassium permanganate causes the decomposition of the ferric compound by the oxidation of the organic "rest" so that the iron gets an opportunity to deposit as the hydrous ferric oxide. $Fe_2O_3(OH)_2$

Water from the Great Dismal Swamp area of North Carolina, the highest colored water ever recorded, is successfully treated with potassium permanganate in small doses, supplementing the chlorinated copperas treatment. This treatment destroys color and organic bound iron, results not accomplished with any other group of coagulants. It is economical and practical and will completely arrest color even in its highest possible ranges and any concentration of naturally occurring organic bound iron.

Potassium permanganate is most effective in the higher pH ranges, that is, 8.8 to 9.8, wherein the iso-electric point of $MnO\,(OH)_2$ lies.

BIBLIOGRAPHY

(1) On the Nature of Colored Water, Jour. New Eng. Water Wks. Assoc., 31, 79, 1917.

(2) Chlorinated Copperas and Ferric Chloride as Coagulants. Virginia Water Purification Conference, April 26, 1929.

(3) The New International Encyclopedia, Vol. 6.

(4) U. S. Dept. Agric. Soil Survey of Pasquotank County N. C.

(5) The Century Dictionary and Encyclopedia.

(6) Atlantis, The Antedeluvian World. Ignats Donnely, Harper Bros. N. Y.

(7) U. S. Coast and Geodedic Survey Charts, no. 452, 1227 and 1228.

(8) Kraft, Chem. Absts., p. 1955, 1913.

(9) The Formation of Humus, Beckley, Jour. Agr. Sci., 11, 69–77, 1921. Synthesis of Humins and Humic Acid, Marcusson, Berlin 54B, 542–5, 1921.

(10) Works of Tetsutare Tadokoro, Jour. College Agr. Hokkaldo Imp. University, 10 part 6, 141–89, 1923.

(11) Synthetic Preparation of Humic Acid, Univ. Jena, Bericht 53B, 1469–76, 1920.

(12) Acid Content of Moor Water, Kurd Indell, J. Pract. Chem., 82. 414–22.

(13) W. Grosspopf, Brennstoff Chem., 7, 293–9, 1926.
(14) Chem. Jour., 40, 224–32, 1927.
(15) Chemistry of Proteins, Mann, p. 88, McMillan and Co.
(16) Proc. Natl. Acad. Sci., 11, 436–8, 1925.
(17) Jour. Amer. Water Wks. Assoc., 20, 4, p. 467–472.
(18) Hopkins and Whitmore, Ind. and Eng. Chem., 22, p. 79, Jan. 1930.
(19) N. C. State Board of Health Files, Sept. 26, 1929 and Engineers report Sept. 22, 23, 24, 1929.
(20) C. P. Mom and O. H. Van Der Hout. Mededeelingen van den Dienst der Volksgezondheid in Ned.-Indie, 1928.
(21) Comptes Rendus, U 162, p. 259.
(22) Dagmar Runehjelm, Biochem. Z., 224, 481–6, 1930.
(23) Prelim. notes, Iron in Fla. Soils, J. Ind. Chem. and Eng., 6, 960.
(24) Transformation of Iron in Nature, Halvorsen H. O., and Starkey R. L., J. Phys. Chem., 31, 626–31, 1927.
(25) The Absorption of Iron by Cellulose, Faserforchung, 8, 55–89, 1930.
(26) Influence of Humus Substance on the Growth of Green Plants, Compt. Rend., Trav. Lab. Carlsburg, 18, 1, 16, 1930.
(27) Studies on the Mode of Combination of Iron with Certain Proteins, Amino Acids and Related Compounds, J. Biol. Chem., 88, 241–69, 1930.
(28) The Hydrous Oxides, Weiser, pp. 34 and 103.
(29) Duncliff and Nijhawn, J. Chem. Soc., 1, 7, 1926.
(30) Rock Pdts., 25, 18, 16–17, 1922.
(31) Mededeelingen Dienst van der Volksgezondheid in Ned.-Indie, 18, 422–30, 1929.
(32) Dennison, J. Agr. Research, 40, 469–83, 1930.
(33) Ann. Sci. Agron. France Etrang., 41, 260, 71, 1924.

CONTROLLING CORROSION OF DISTRIBUTION SYSTEMS

By Abel Wolman

(*Chief Engineer, Maryland Department of Health, Baltimore, Md.*)

One of the interesting results of the increasing demand of the public for improved quality of public water supplies is its requirement that the water at the faucet should be clear and colorless. The production of a clear and colorless product is not so simple, because of the corrosive character of the water at its source or after its treatment. Corrosiveness is particularly associated with waters of underground origin, as these frequently carry high amounts of dissolved oxygen and carbon dioxide and small amounts of soluble salts.

Within recent years more and more effort has been devoted to reducing the destructive action of some waters on the pipes which carry them to the consumer. These efforts are based upon fairly simple chemical concepts and in many instances are not costly.

The Bureau of Sanitary Engineering of the State Department of Health of Maryland has been called upon in the last few years to recommend procedures for the elimination of the corrosiveness of several public water supplies. Data have been accumulated as to the causes of such corrosion and as to processes which materially reduce or eliminate these disabilities. The practical results obtained in full scale operation in some of these cases are here reported.

Measures for the reduction or elimination of corrosion of the distribution system have been introduced for the treatment of the water supplies of a number of small communities in Maryland, covering a total population of between 25,000 and 30,000. They are referred to here in individual examples with sufficient analytical data to make clear the principles of treatment.

OVERLOOK, LINTHICUM HEIGHTS, SHIPLEY HEIGHTS AND FERNDALE

Since January 1, 1928, water is being obtained for these communities from a Layne-Atlantic well, which replaced a number of 4-inch driven wells and one dug well. The water is distributed from an elevated tank by gravity to the communities named.

In the summer of 1928, a preliminary examination of this supply was made to determine the corrosive properties of the raw water at the well and the effects of such corrosion at various points in the distribution system. As a measure of the extent of corrosion, the drop in dissolved oxygen between the source of supply and the tap under examination was used.

Before this water supply was treated all the taps examined on the distribution system exhibited a reduction in dissolved oxygen. As will be noted from the data in table 2, the raw water constituents indicated probable corrosive properties of high degree.

Preliminary laboratory tests were made to determine how the CO_2 in the raw water could be materially reduced. Aeration alone, while effectively reducing the free CO_2 content, did not produce a hydrogen-ion concentration sufficiently high to prevent continuance of corrosion, in view of the great amount of dissolved oxygen normally present in the water.

As a result of the laboratory tests the Bureau recommended aeration, followed by the application of lime at the rate of from $\frac{3}{4}$ to 1 grain per gallon. Sodium silicate and sodium silicate with caustic soda were given some consideration as alternatives, but they were not recommended on account of their relatively higher cost and the greater number of unknowns in their use.

As a result of our recommendations, treatment of the supply was instituted in March, 1929.

Detailed information on the aeration equipment is shown in table 1. In addition to aeration, lime is applied to the aerated water at the rate of approximately 0.75 g.p.g.

Following the installation of the treatment devices, additional determinations have been made upon the distribution system. The results of these findings are shown in table 2. The corrosion effects, as indicated by drops in dissolved oxygen, still persist at station 1, indicating that unprotected steel mains, with the character of water supply here in use, may not be economical installations.

The treatment equipment was designed and constructed by Mr W. C. Munroe, Chief Engineer for the Anne Arundel County Sanitary Commission, which controls these systems.

GLENBURNIE

Glenburnie has been supplied, since 1928, by a flowing well of the Layne-Atlantic type. This raw water is saturated with dissolved oxygen. It has a pH averaging 5.2 and contains reasonably high

TABLE 1

Design features of aeration plants in Maryland (for prevention of corrosion)

PLACE	TYPE	NUMBER OF TRAYS	VERTICAL SPACING	AREA	DEPTH OF WATER OVER TOP TRAY	G.P.M. PER SQ. FT.	OPERATING RATE	HOLES IN TOP TRAY	REMARKS
			inches	*sq. ft.*	*inches*		*g.p.m.*		
Overlook and vicinity	Flat trays, no medium	6	12	9	4	17−	150	Holes of sufficient size, 1 inch centers to keep 4 inch head	Operates with 5 inch depth
Glenburnie	Flat trays, no medium	7	12	16	4	19	300	$\frac{3}{8}$ inch diameter at required spacing to keep 4 inch head	
Salisbury	Coke	1 flat, 4 coke	9 clear, 10 coke	48	2	21−	1,000	$\frac{1}{2}$ inch diameter, 4 inch centers	Can run at 30–35 g.p.m. per sq. ft.
Pocomoke	Coke	1 flat, 4 coke	9 clear, 10 coke	32	2	16−	500	$\frac{1}{2}$ inch diameter, 4 inch centers	Can run 600 g.p.m.

TABLE 2

Overlook, Linthicum Heights, Shipley Heights and Ferndale—Characteristics of water supplies before and after treatment to reduce corrosion

	RAW WATER	RAW WATER AERATED	RAW WATER AERATED AND LIMED	STATIONS 1 Steel main 2000 ft.	2	3	4	5	6 Established in Ferndale in March, 1930	7 Established in Ferndale in March, 1930	DATE OF EXAMINATION
Before treatment											
D. O	106.2			3.5	89.1	84.7		70.0			April, 1928
CO_2	20.0	4.0		18.0	14.0	16.0	18.0	17.0			
pH	4.2	6.3		5.5	5.5	5.4	5.3	5.5			
After treatment											
D. O	67.0	67.0	63.8	24.4	60.9	58.3	58.4	60.0			March, 1929
CO_2	23.0	11.0	2.0	2.0	2.0	2.0	2.0	1.0			
pH		6.0	7.2	7.0	6.9	7.0	6.8	7.0			
D. O	91.7	105.4	119.2	53.2	118.9	90.1	119.6	109.9			July, 1929
CO_2	28.0	8.0	1.0	5.0	0.5	0.0	4.0	0.0			
pH	6.0−	6.0−	7.9	7.1	7.5	7.6+	7.6+	7.6+			
D. O	105.9	112.1	111.9	49.1	119.0	109.2	125.3	105.0			December, 1929
CO_2	13.0	2.0	0.5	1.0	5.0	0.5	0.0	0.5			
pH	5.8	5.9	7.5	7.1	7.5	7.6	7.8	7.7			
D. O	101.6	102.5	104.3	57.8	109.5	93.6	103.4	91.5	79.0	55.3	March, 1930
CO_2	16.0	4.0	0.0	1.0	1.0	1.0	0.5	1.0	0.0	1.0	
pH	5.5	5.8	8.8	7.3	7.1	7.2	7.5	7.4	7.9	7.3	

D. O.	100.0	100.6	90.3	47.7	94.9	88.7	104.1	117.8	61.5	42.3	December, 1930
CO_2	19.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
pH	5.5	5.9	8.1	8.4	8.0	8.2	8.2	8.2	8.1	8.1	
D. O.	91.5	96.5	94.5	94.0*	91.3	91.4	90.6	89.2	90.0	90.4	February, 1932
CO_2	15.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
pH	5.6	5.9	8.3	8.4	8.3	8.3	8.4	8.5	8.5	8.5	

D. O. figures in percent saturation. CO_2 figures in p.p.m.

* Steel main replaced by cast iron mains, 1930.

amounts of CO_2. These probable corrosive properties of the raw water were confirmed in our study in 1928 of the distribution system. All samples drawn from taps in the distribution system showed reductions in dissolved oxygen content of considerable amount. As is to be expected, the samples from hot water taps showed the greatest reductions in oxygen content. These findings are presented in table 33 covering observations in 1928, 1929 and 1930.

TABLE 3

Glenburnie—Characteristics of water supply at the source and at points on the distribution system before and after treatment

	Raw water	Raw water aerated	Raw water aerated and limed	Stations 1	2	3	4	5	Date of examination
				Before treatment					
D. O.	89.6			76.7	74.1	62.1	73.3	81.7	April, 1928
CO_2									
pH	5.2			5.2	5.2	6.6	7.0	5.4	
D. O.	97.0			70.4	83.1	84.9	92.5	102.2	November, 1929
CO_2	10.0			11.0	9.0	8.0	7.0	11.0	
pH	5.6			5.9	5.9	5.9	5.9	5.8	
				After treatment					
D. O.	87.7	94.2	97.9	95.7	88.7	88.7	96.2	96.2	March, 1930
CO_2	12.0	2.0	2.0	3.0	1.0	1.0	1.0	1.0	
pH	5.5	6.0	6.0	6.9	6.8	6.8	6.8	6.9	
D. O.	83.1	92.3	90.0	88.7	83.8	89.4	91.8	105.5	February, 1932
CO_2	11.7	3.6	0.9	1.8	Trace	0.0	Trace	Trace	
pH	5.5	5.9	6.7	6.9	6.8	6.9	6.9	6.9	

D. O. figures in percent saturation. CO_2 figures in p.p.m.

Laboratory tests on the Glenburnie raw water indicated that successful reduction of these corrosive properties could be accomplished with aeration and a subsequent application of lime at the rate of about one grain per gallon.

A treatment plant embodying these recommendations has been constructed under the supervision of Mr. W. C. Munroe, Chief Engineer of the Anne Arundel County Sanitary Commission. Details of the aeration equipment appear in table 1.

The results of resurveys of this distribution system in March, 1930, and February, 1932, after the completion of the treatment plant, are shown in table 3.

SALISBURY

The public water supply for the City of Salisbury is obtained from the Kelly type of wells. The characteristics of the waters of these wells are shown in table 4. Included in this table are similar data for various taps on the distribution system,[1] showing the effects of aeration alone and of the full corrective treatment with both aeration and lime.

The treatment of this supply, installed as a result of our laboratory tests for the prevention of corrosion, consists of coke tray aeration and lime application to maintain an average pH of 7.8 on the distribution system. This is now being accompanied by a dosage of about 0.3 g.p.g. of lime. The details of this installation are shown in table 1. The results of this form of treatment are presented in table 4.

This plant was designed and constructed upon our recommendations by Mr. F. H. Dryden, Chief Engineer of the Salisbury Water and Sewerage Commission.

POCOMOKE CITY

A similar installation has been designed and constructed by Mr. Dryden for the public water supply of Pocomoke City. It is now in successful operation. The units of design are shown in table 1.

CROWNSVILLE STATE HOSPITAL

The Bureau of Sanitary Engineering has constructed a plant for the correction of the corrosive properties in the waters of deep wells at the Crownsville State Hospital for the Colored Insane. The plant consists of aeration, lime and alum treatment, settling and filtration.

The well waters carry high amounts of CO_2, of dissolved oxygen and in some cases of iron. This water supply has been the source of considerable difficulty in the distribution system for a great many years. For a time it was used without lime and soda ash application with considerable destructive action on the mains. Afterwards lime and soda ash treatment was instituted, but with inadequate mixing and reaction time and with unsatisfactory filtration provisions. The

[1] No survey of the distribution system was made prior to the installation of the aerator.

TABLE 4

Salisbury—Characteristics of water supply at the source and at points on the distribution system with partial and complete corrective treatment

	RAW WATER	RAW WATER AERATED	RAW WATER AERATED AND LIMED	STATIONS 1	2	3	4	5	6	7	9	10	11	12	13	DATE OF EXAMINATION
With aeration alone																
D.O.	98.0	103.7		105.8	83.1	100.6	68.8	104.8	101.2	66.2	83.8					May, 1928
CO_2	16.0	3.7		2.5	2.5	3.5	5.0	4.5	5.0	3.7	3.0					
pH	5.9	6.5		6.9	6.7	6.6	6.3	6.3	6.3	6.5	6.6					
D. O.	58.8	89.6		79.2	81.2	81.0	66.8	82.3	76.5	84.5	60.6	Lime omitted due to misleading pH readings caused by deteriorated indicator solution				December, 1930
CO_2	11.0	3.0		2.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0					
pH	5.9	6.6		6.7	6.4	6.4	6.9	6.4	6.7	6.4	6.8					
With aeration and lime																
D. O.	83.7		100.5	103.7	105.3		78.4			91.3	90.9	78.0	88.0	95.5	63.9	June, 1931
CO_2	11.0		Trace	Trace	Trace		0.0			Trace	Trace	0.0	0.0	Trace	0.0	
pH	5.8		7.8	7.8	7.8		8.4			7.8	7.8	8.4	8.4	7.8	8.4	
D. O.	75.9		90.3	96.3	96.3		80.3			94.5	81.8	96.0	80.3	82.9	84.7	December, 1931
CO_2	12.6		0.0	3.6	0.0		0.0			0.0	0.0	0.0	0.0	0.0	0.0	
pH	5.8		8.4	7.8	8.2		8.4			8.0	8.4+	8.4+	8.4+	8.4+	8.4+	

D. O. figures in percent saturation, CO_2 figures in p.p.m.

results of the two forms of operation of this supply, one without attempt to control corrosive action and the other with inadequate control, are shown in table 5. In table 5 the analytical tests of deposits taken from one of the mains at this hospital are presented, in order to show the totally different chemical character of the deposits, laid down in the same main during consecutive periods of operation. The first column in table 5 shows the accumulation resulting from destructive action on the cast-iron main, while the second column shows the deposit of excessive amounts of applied lime later accumulated on the iron deposits of earlier years. Both classes of deposition in the same main demonstrate the inadequacy of previous operation and of probability of relief with more careful chemical control in the new plant.

TABLE 5

Crownsville State Hospital—Analyses of scales from water supply pipes before and after treatment

CHARACTERISTIC ION	PERCENT IN SCALE ON PIPE	
	Before treatment	After uncontrolled treatment with lime
Ferric	57.7	2.1
Calcium	0.6	41.4
Magnesium	0	0
Sodium	0	0
Sulphate	0	0
Carbonate	0	13.0
Loss on ignition	13.7	5.4

CONCLUSIONS

The records briefly presented above demonstrate the economic possibility of preventing or reducing the disintegration of distribution systems of public water supplies, by simple aeration and chemical treatment. Simple and practicable units of measure in the initiation of such a program and in its continued control are available in tests for dissolved oxygen, pH and carbon dioxide.

Acknowledgment is here made of the highly coöperative spirit of Messrs. Munroe and Dryden in the development of the Bureau's investigations; to T. C. Schaetzle (formerly of this Bureau), M. H. Coblentz, A. W. Blohm and J. R. McComas of the Bureau for their field studies and office preparation of much of these data.

METERS FOR MEASURING COLD WATER

By Louis Mitchell

(*Dean, College of Applied Science, Syracuse University, Syracuse, N. Y.*)

In 97 AD. Sextus Julius Frontinus was appointed "Commissioner of Water Works" of the City of Rome. The high character and intelligence of this official is revealed in his classic treatise "De Aquis" which is a technical account of the earliest known municipal water supply system.

This ancient record of 18 centuries ago shows that Frontinus, like the modern water works official, was faced with the problem of measuring both supply and distribution. However, this old Roman was seriously handicapped because only a meager store of hydraulic knowledge was available. Probably because there was no means of accurately recording seconds or small intervals of time, Frontinus apparently did not grasp the idea of velocity as a function of discharge in the now familiar equation $Q = AV$, and hence made his comparison of the discharge of pipes and channels on the basis of cross sectional area alone, as if Q were equal to A times some constant. It is small wonder that he was often baffled by the inconsistencies in his computations.

However, Hero of Alexandria, the inventor of the steam engine, a contemporary of Frontinus and perhaps his teacher, described the method of measuring the yield of a spring as follows:

> "Observe always that it does not suffice to determine the section of flow to know the quantity of water furnished by the spring; . . . it is necessary to find the velocity of the current . . . . for this reason, after having dug a reservoir under the stream, examine by means of a sundial how much water flows into it in an hour and from that deduce the quantity furnished in a day."

This is the earliest record of the true conception embodied in the principle of volumetric metering.

From the Roman water supply system to the present day is a long time, but modern methods of meterage are less than a century old.

This is because modern water supply systems are of comparatively recent origin. In 1850 only 83 municipal systems were in existence in the United States. Obviously until they became more common there was no demand for devices which would measure quantities of water.

Meterage for distribution systems, while not yet universally adopted, is so generally used as to establish its merit beyond question, although flat rate service makes a special appeal in some communities and under certain conditions may actually result in a higher revenue. As a general rule universal metering of services reduces waste, usually increases revenue and improves service without reducing legitimate uses of water.

Complete meterage of a water system enables the water works superintendent, if he desires, to balance his supply against his distribution in the same manner that his bookkeeper balances his cash receipts and expenditures, and while of course all of the water cannot be accounted for, checks of this kind are useful in keeping to a minimum the amount of water that can only be charged to waste and leaks.

The fact that, once installed, no community has ever discarded its meterage system is strong evidence that the principle is sound, practical and fair alike to those who sell and those who purchase water.

TYPES OF METERS

Present day water supply systems make use of various kinds of water meters. These may be divided into two general groups, those which measure quantity or volume only and those which measure the rate of flow.

The former include such meters as displacement, current or velocity, compound and fire service meters. The latter group includes the types that make use of the Venturi and the Pitot principle, which can also be used in connection with a registering device so that not only the rate of flow, but also the volume of discharge can be determined.

Meters are manufactured by a dozen or more different companies. From the standpoint of the purchaser he should be assured that the product he buys is

a. Accurate as to registration,
b. Sufficient as to capacity,

c. Does not have excessive loss of head,
d. Durable,
e. Built of good materials by precision workmanship,
f. Easy to repair,
g. Manufactured by an established company that can always supply parts,
h. Reasonable in cost.

All cold water meters of the volumetric type such as disc, current, compound and fire service meters are designed to meet the standard specifications of the American Water Works Association (adopted May 24, 1923) and the New England Water Works Association (adopted March 18, 1923). These specifications are considered as standard by many water departments and their adoption as at least minimum requirements should be encouraged as suitable for all water works, large and small. They protect the purchaser as to accuracy of registration, capacity, workmanship and materials.

Displacement meters of the disc type range in size from $\frac{5}{8}$ to 6 inches, the smaller sizes having a wide use in metering house services.

The ease with which meters may be repaired has an important bearing on the maintenance cost and if they are furnished by established and reliable companies there is the assurance that parts for repairs will always be available. Where house meters are purchased in quantities, precision workmanship will insure that the meters supplied are uniformly accurate and reliable. As far as cost is concerned the marvel is that these meters, especially the small house meters, can be put on the market for the low initial cost that is charged.

In addition to the Standard Specifications of the water works associations the Public Service Commission in New York State has established rules and regulations governing the testing of water meters of water works corporations. However, these apply only to corporations which are privately owned. Municipal supplies are exempt from the jurisdiction of this Commission.

Compared with the standard specifications of the water works associations these regulations impose a higher degree of accuracy as far as over registration is concerned and except for the disc meter allowed a lower degree of accuracy for under registration. The percentage of error allowable for under registration of the disc meter is the same as the standard specifications.

A comparison of the requirements in terms of percentage for regis-

tration of meters with reference to the quantity of water actually passed through the meters under identical conditions of the test flow is shown in table 1.

As will be noted, the regulations of the Public Service Commission in this matter are entirely to the advantage of the purchaser of water.

Current meters are manufactured in sizes from 1½ to 20 inches, although sizes above 12 inches in this type of meter are rarely used.

These meters, unlike the displacement meter, are not positive in action but are so constructed and calibrated that the volume of flow corresponds to the number of revolutions of the wheel or propeller that is used. Some makes use one and others two wheels on the shaft. These meters are sometimes referred to as velocity meters. They have a field of service where heavy flows and high pressures are encountered and where the registration of small flows is not relatively

TABLE 1
Comparison of requirements for percent registration

TYPE OF METER	PUBLIC SERVICE COMMISSION		WATER WORKS ASSOCIATIONS	
	Not less than	Not more than	Not less than	Not more than
Displacement	98	101	98	102
Current	96	101	97	103
Compound	96	101	97	103
Fire Service	96	101	97	103

important, and have the advantage of low initial cost. In the operation of these meters it is important that the screen surrounding the wheel and be kept free from leaves or débris as clogging reduces the area of the opening and changes the characteristics of the velocity so that the meter will over register.

Compound meters have a field of application where it is necessary to register both small and large rates of flow. These meters are a combination of a small displacement meter for measuring low flows and a current or velocity type meter for measuring large flows. The meter is built as a complete unit or the small flow meter bypass may be obtained as a separate unit and installed in connection with an ordinary current or velocity meter.

These meters are very accurate and are suitable for services where flows are intermittent. The design is such that it will register the

small rates of flow such as are represented by domestic services and also heavy flows which would be drawn by commercial services or fire draughts.

While the general accuracy of meters of this type is high, tests show that they are the least accurate within the "change over" from the small flow meter to the main line meter. The standard specifications state that registration at these rates of flow shall not be less than 85 percent.

A limited number of tests on this type of meter shows that the percentage of error at the point of "change over" is not the same when the rate of flow is being increased through the meter as it is when the rate of flow is being decreased. Plotted on a diagram the dip in the curve does not always occur at exactly the same place and for decreasing rates of flow is usually lower. However, sufficient data are not available for definite conclusions, but the suggestion is made that additional experimental work be carried out to clearly establish the characteristics of compound meters in this respect.

The *fire service meter* is a compound meter having a small bypass meter of the displacement type for measuring small flows but the main line meter is of the proportional flow type so that a large proportion of the flow, about 75 percent, can pass through an unobstructed opening. The proportional flow, about 25 percent, is diverted and measured through a current or velocity meter.

Rate of flow meters operate either on the Venturi or Pitot principle. They are used for small flows as well as large capacities beyond the range of Volumetric meters. They can be, and usually are, installed in connection with registering devices and clock mechanisms so that continuous records of variations in rates of flow can be made as well as determinations of the total quantity of flow.

It is not within the scope of this paper to discuss the various registering devices, some of which are mechanically and others electrically operated, but it may be stated that they can be used with either type of meter element.

Rate of flow meters which operate on the Venturi principle may be Venturi tubes, orifice plates or flow nozzles.

Venturi tubes can be secured as commercial meters in sizes from 2 to 48 inches and over. Often the larger sizes are built of concrete, the throat section and upstream pressure ring being furnished by the manufacturer.

The Venturi meter is made in sections with smooth interior sur-

faces so that the friction loss is a minimum. As the pressures are read from annular chambers which communicate with the interior of the meter through a number of small holes, accurate measurements of the pressure are made possible. This is an important feature of this type of meter as the rate of discharge varies as the square root of the difference in pressure.

The orifice and flow nozzle meters also operate on the Venturi principle but the meter element is much simpler. The orifice consists essentially of a circular sharp edged, but not beveled, orifice in a circular plate placed in the pipe line between flanges. The materials used are commonly brass or monel metal.

The flow nozzle is a device similar to the orifice plate except that a short nozzle attached to a plate is placed inside the pipe line and the flow of water takes place through this nozzle.

These meters are calibrated and meter constants or scales are furnished by the manufacturers.

Meters employing the Pitot principle measure the dynamic pressure produced by the velocity of water flowing in the pipe line. These meters may consist of rods or of tubes containing two small orifices or openings, one pointing upstream and the other either at right angles to the direction of flow or down stream. The difference in pressure produced is a function of the velocity.

The meter rod is inserted in the side of the pipe through a stuffing box connected with a corporation cock so that the orifices may be placed at any desired point within the pipe. After a traverse of the pipe is made and the pipe coefficient determined, the orifices can be set at the center of the pipe and continuous readings taken.

The difference in pressure produced by meters of the Venturi type is usually read by the displacement of mercury in a U tube or chamber. Since the velocity head of flowing water is relatively small, differential gauges using mercury are unsuitable for meters of the Pitot type and the liquid used for differential pressure readings for such meters is usually carbon tetrachloride (specific gravity 1.60) or a mixture of carbon tetrachloride and benzine which may have a specific gravity as low as 1.25.

It may also be noted that for the latter specific gravity, i.e., 1.25, the actual difference in pressure as read on the U tube would be four times as great as the actual difference in pressure head of water. The difference in pressure head is therefore in a sense amplified and small errors in measuring the pressure head on the U tube are made

negligible whereas with the mercury differential gauge, specific gravity 13.59, errors are magnified in the ratio of about 1 to 12.

Each type of primary meter elements, whether it be of the Venturi or Pitot type, has its advantages and disadvantages and the selection of one particular kind requires consideration of such points as initial cost, cost of installation, accuracy, arrangement of the pipe layout, capacity desired and the pressure loss that is allowable.

COSTS AND OPERATING CHARACTERISTICS

Orifices are usually lowest in initial cost with flow nozzles next and Venturi tubes considerably higher in price than the other two types. Pitot tubes complete sell for about the same price as orifices and recorders in the smaller sizes, but the larger sizes are cheaper than any of the other primary elements.

Pitot tubes are as a rule the cheapest to install as they require only a one inch corporation cock tapped into the pipe line. Orifices are economical to install and flow nozzles cost but little more. Venturi tubes, usually a part of a permanent installation, are the most expensive to put in place.

Although the Pitot meters have the advantage of low initial cost and installation, there is a tendency for the small openings to clog and if this occurs it will cause inaccuracies in the meter readings. Where the water carries silt or sediment this is a point to consider, especially if the meter is a permanent installation. For use in waste water surveys however this type of meter is indispensible.

While the Venturi tube involves a higher cost, it has the advantage of being fool proof and less likely to need repairs or maintenance.

A high degree of accuracy may be obtained with the Venturi, orifice, flow nozzle or Pitot meters. That is, an accuracy within plus or minus one percent over a wide range of capacities. Venturi tubes are made as small as 2 inches and Pitot tube meters can be used on all sizes of pipe above 4 inches.

Venturi tubes or flow nozzles require less straight pipe preceding them than orifices or Pitot tubes, other conditions being the same.

Pitot tubes produce practically no loss of pressure in the pipe line as the meter rod is narrow and does not interfere appreciably with the flow. Venturi tubes produce a pressure loss which is considerably lower than that introduced by either the orifice or flow nozzle and therefore have the advantage where the loss in pressure is an important consideration. Where water is to be pumped the

actual saving in pumping cost due to use of a Venturi tube rather than an orifice or flow nozzle, can be computed and this saving weighed against the additional cost of the Venturi tube.

The head lost in orifice plates may reach as high as 88 percent of the total differential head when the ratio of the orifice diameter to pipe diameter is $\frac{1}{3}$. The ratio, except in special cases, does not exceed $\frac{3}{4}$ at which point the percentage of lost head is somewhat below 50 percent of the total differential head.

Orifices and flow nozzles designed for the same conditions of flow produce practically the same pressure loss, and, as has been indicated, for the same size of main pipe this loss increases rapidly as the diameter of the orifice is decreased. The loss approaches more nearly that of the Venturi tube when the diameter of the orifice reaches its maximum. Inasmuch as orifices and flow nozzles can be designed for higher capacities than Venturi tubes, in some instances the former type of primary element produces net pressure losses even less than that of the Venturi tube since a lower head meter can be used with them.

The basic capacity of a Pitot tube is fixed by the size of the line in which it is installed, although some modifications are occasionally made in the design of the tube and by the insertion of nozzles in the line to decrease its diameter and increase the flow velocity at the point where the tube is installed. In general, however, Pitot tubes are inflexible as to capacity, but their capacity is higher than that obtainable with orifices or flow nozzles. Also, velocities as low as one half foot per second can be read with these meters.

For a given set of conditions the flow nozzle would come next to the Pitot tube in measuring highest capacity and the orifice would come next. A Venturi tube ordinarily has a maximum ratio of throat to diameter of 50 percent. It is limited to ratios of 70 percent or below by characteristics of its coefficients and therefore cannot be designed for as high a capacity as the orifice or the flow nozzle since the former can if desired be designed for ratios as high as 90 and the latter as high as 85 percent respectively, without sacrificing accuracy, provided of course that the layout of the piping is satisfactory.

No attempt will be given to state exact costs of meters as these will naturally vary with different styles and also with the number ordered.

In general, however, the cost of the ordinary $\frac{5}{8}$-inch house meter is in the neighborhood of $10. Some are a few dollars more or less. A

6-inch current or velocity meter will cost about $350, while a compound meter of the same size will be approximately $525. The 6-inch fire service meter will cost about $500.

Venturi tubes range in price from $55 for the 2-inch size to over $3000 for the 48-inch tube. The price of orifice plates varies, from about $7.50 for the 3-inch size to $120 for the 24-inch plate. These prices, however, are for the water meter element only and do not include the cost of registering devices.

A 4-inch orifice meter and electrically operated recorder will cost about $335 and the 36-inch size about $400.

In the preparation of this paper, the author has drawn heavily upon the oral and written ideas of others whose practical experience in problems of meterage has been greater than his own, and in conclusion his thanks to these various gentlemen are extended.

(Presented before the New York Section meeting, April 8, 1932.)

PERSPECTIVE IN PURIFICATION EXPENDITURES

By George B. Prindle

(*Superintendent, Water Works, Highland Park, Ill.*)

While the history of public water supplies dates back to ancient times, and records many early examples of admirable works, such as those built by the Romans, it is only within the present century that widespread public interest has been aroused in the *quality* of the water that these works were dispensing. However, once having become water conscious, the public has not only been keeping step with the advances made by the profession, but has often led the race in its insistent demands for a better product.

A generation ago, if water was clear and cold it found a ready market. Soon the bacteriologists, who previously had with difficulty sold their knowledge to the metropolitan areas, found their doctrine being listened to in the smaller cities and rural districts. Water filtration plants were in demand, and sterilization by chlorine came into its own. Interesting things happened in the records of public health officials. Water borne diseases, which had scourged the world since time immemorial, were on the run. Soon it was demonstrated that they could be abolished, and the public gave whole hearted assistance in the fight. No longer was it necessary to urge the people to use safe water—unless they were convinced that it *was* safe, they would have none of it.

Once having started the march of progress, nothing could stop it, not even the members of the water works profession, had they been so minded. From clear water the public demand progressed to clear and safe water. The next step was logical, and we found our customers insisting that the water we served should be clear, safe, and reasonably soft. The chemists and engineers went to work, and plants for the removal of excess minerals were the result. But the task was not finished. The public soon discovered that some water supplies were much more palatable than others, and the science of taste and odor control was born.

Meanwhile the plant operator was doing his best to keep up with

the parade. Sometimes this was difficult for lack of funds, or lack of equipment, or both. Sometimes the trouble lay within himself—perhaps he had the tools to work with, but was timid about using them. Again, he may have resented any expenditure which would alter his carefully built-up record of economical operation. Unfortunately the public is not interested in these considerations. It wants good water, and means to get it. What are we going to do about it?

Perhaps, if we back off, and look at the picture as a whole, the problem will seem less difficult. And therein lies the purpose of this paper. If we are alarmed at the prospect of additional expenditures, made necessary by this new demand, they may prove to be very small, if we view them with the right perspective.

A great many costs are involved in furnishing the public with water. If we start with the source of raw supply, and carry through the numerous steps until we reach the tap of the consumer, giving each step, and sub-step, its proper capital and operating charge, we will have built up an elaborate computation. However, many of these charges are fixed beyond the power of the operator to alter. For example, he may draw his raw supply from a lake or a river, at little or no expense, while a neighboring plant may have required the building of a costly artificial reservoir to meet its demands. Again, his plant may have been skillfully designed, and add a minimum of capital cost to those of operation, or it may have been poorly conceived, and be overly expensive for the work it performs. Further, the costs of distribution vary widely, and are beyond his control. For these reasons the comparisons drawn in this paper will be confined entirely to plant operating costs—that is, to those items of expense which are directly under the control of the operator, and which to some extent, at least, he may vary at will.

As no two plants have identical operating conditions we are confronted with another stumbling block in drawing general conclusions. Therefore, it has seemed best for the purposes of this discussion that we set up what may be assumed to represent a fair average of the conditions with which the Illinois operators have to deal.

ASSUMPTION

First, let us assume that our average plant is typical of many works constructed in the past decade, and that it is a combined pumping station and filtration plant. Second, we will omit water softening

from our discussion, as affecting a minority of plants in this state, and as involving too many variables for the scope of this paper. Third, we will assume that the plant is operated electrically, and that the purification and the pumping—including the high lift—are under the control of the operator. Fourth, we will assume that the purification consists of coagulation with alum; sedimentation; sterilization with ammonia and chlorine; rapid sand filtration; and odor control by the use of powdered activated carbon.

On this basis we will attempt to work out approximate average unit costs. It will be understood that some items must be fixed rather arbitrarily, where there seems no rational method of arriving at close values. In such instances the advice of other members of the association has been freely sought. First, we will set up our average conditions.

Assumed typical operating conditions

Pumping Heads, in feet:
Raw water, 30
Wash water, 40
Clear water, 170

Efficiencies, percent:
Overall efficiency of pumping units, 70

Wash Water Used:
3 percent of raw water

Unit Prices:
Energy, 1.5¢ per KWH
Alum, $1.25 per cwt.
Ammonia, 16.5¢ per pound
Chlorine, 7.5¢ per pound

Average Chemical Treatment:
Alum 1.5 grains per gallon
Ammonia 1.5 pounds per million gallons
Chlorine 3.0 pounds per million gallons
Carbon 20 pounds per million gallons

Supervision and Labor:
$20 per million gallons

Heat, Light, Supplies and Maintenance:
$2 per million gallons

It is believed that the indicated pumping heads are fairly representative, and that the overall efficiency selected for the units will not be exceeded in the average Illinois plant. The advice of manufacturers was followed in arriving at unit prices typical of the state.

It is recognized that plants handling relatively clear lake water may possibly obtain satisfactory results with less than half the indicated dosage of coagulant, but these plants are only a part of the picture.

It was quite difficult to arrive at a satisfactory labor charge per million gallons. In general, this varies inversely with the size of the plant. In very small works, despite the few number of employees, and their relatively small compensation, the charge may be very high, owing to the small water output. The evidence indicated a range from about $50 per million gallons in the smallest plants to less than $10 in the largest. A figure of $20 per million was believed to be fairly representative.

An item of $2 per million gallons was included for heating, lighting, supplies and maintainance, but no figure has been included for plant depreciation, which like interest on the investment is not an expense under the control of the operator. For the same reason no recognition will be made of the loss of head between the elevation of the water in the sedimentation basin and that in the clear well. This head loss is chargeable entirely to purification, but being inherent in the plant design is not alterable, except as favorable operation can keep it near its theoretical minimum.

COST OF WATER

On the basis of 1.5 cents per KWH energy rate, and an overall efficiency of 70 percent for pumps and motors, the unit cost for water pumped would be 6.73 cents per million-gallon-foot, and this figure will be used in the computations.

As the water used in washing filters is *filtered* water, its cost includes; first, its pumpage as raw water; second, its chemical treatment; and, third, its pumpage as wash water. These steps will be indicated.

No division of labor charge will be made between purification and pumping. In the average plant supervision and labor constitute a relatively fixed item, which does not change with the variable purification costs or with pumping loads.

On the above assumptions, we now find that the water pumped out of our hypothetical average Illinois plant will cost as shown in tables 1, 2, and 3.

From these comparisons it will be seen that the total variable purification costs are but 12 percent of the operating expenses.

The cost of sterilizing chemicals—chlorine and ammonia—is proportionately so insignificant that there is little tendency on the part of plant operators to make unwise economies in their use. The same can not always be said of the feeding of coagulants. While to use more alum than is necessary is both wasteful and detrimental to the

TABLE 1

Operating costs per million gallons

	DOLLARS
Raw water pumpage, 30 feet × 6.73¢	2.02
Alum, 214 pounds @ $1.25 per cwt	2.68
Ammonia, 1.5 pounds @ 16.5¢	0.25
Chlorine, 3.0 pounds @ 7.5¢	0.23
Carbon, 20 pounds @ 7.0¢	1.40
Wash water, 3 percent × ($6.58, the cost of filtered water as above, plus 40 feet × 6.73¢)	0.28
Clear water pumpage, 170 feet × 6.73¢	11.44
Supervision and labor	20.00
Heat, light, supplies and maintenance	2.00
	$40.30

TABLE 2

Operating costs grouped in order of magnitude

	DOLLARS	PERCENT
Supervision and labor	20.00	49.6
Clear water pumpage	11.44	28.4
Alum	2.68	6.6
Raw water pumpage	2.02	5.0
Heating, etc	2.00	5.0
Carbon	1.40	3.5
Filter washing	0.28	0.7
Ammonia	0.25	0.6
Chlorine	0.23	0.6
	$40.30	100.0

chemical characteristics of the finished water, nothing can be said in favor of imperfect flocculation due to under dosage. It must not be forgotten that the whole theory of rapid sand filtration is predicated on chemical coagulation and sedimentation, and that this can not be accomplished without coagulants.

One of the most frequently practiced false economies is in the use of wash water. There is but one reason for washing filters—to get them clean. If we do less than this, we are storing up future trouble. Not so long ago we were taught that it was wrong to wash a filter too clean—that a certain amount of sediment should be left in the bed to seed it, as it were. That theory, which was a relic of the old slow-sand-filter days, has been exploded. There is no such thing as a too-clean filter bed. Most operators, if they are able to get long filter runs, pride themselves on the accomplishment. If it has been done without sacrificing the condition of the sand, it deserves praise. On the other hand, if the bed has been left in service until it has accumulated more dirt than will be removed by the wash, the practice is a mistake—and I speak from experience.

TABLE 3

Operating costs grouped by divisions

	DOLLARS	PERCENT
Supervision and labor	20.00	49.6
Pumpage, raw and clear	13.46	33.4
Purification costs:		
Alum, Carbon, Filter washing, Ammonia, Chlorine	4.84	12.0
Heating, etc	2.00	5.0
	$40.30	100.0

Many plants are not equipped to give the higher rates of wash which recent experiments have proven beneficial. But we can all wash our filters more often, and for longer intervals. We have seen that in our hypothetical plant the cost of using 3 percent of wash water was but 0.7 percent of the total operating charges. Should we double this, we would have added but 28 cents per million gallons to the cost of the water pumped into the mains. Money spent in this direction may often prevent otherwise serious and mud-ball trouble.

The most recent cost which we have added to our purification schedule has been by the use of activated carbon. In our typical plant it has been included at $1.40 per million gallons. While this may seem high, it only represents 3.5 percent of the operating total.

What are the benefits? If by its use we have turned a disagreeable water, with a medicine-like taste, into a delectable drink, over which our customers enthuse, it has been worth the cost. It is said that the average citizen is quite oblivious to the water system which serves him, except when two things happen—a disagreeable taste appears, and when he gets his bill. We may not be able to help in the latter difficulty, but if we are skillful in the use of carbon we should be able to prevent the first.

PUMPING COSTS

Looking back over our typical operating costs, we find that energy for pumping raw and clear water came to $13.46 per million gallons.

TABLE 4

Cost of raising water 200 feet with electrically driven pumping units of varying efficiencies

(Energy rate 1.5¢ per KWH)

OVERALL EFFIENCY, PERCENT	COST PER M. G., DOLLAR	OVERALL EFFIENCY, PERCENT	COST PER M. G., DOLLAR
60	15.70	71	13.27
61	15.44	72	13.08
62	15.19	73	12.90
63	14.95	74	12.73
64	14.72	75	12.56
65	14.49	76	12.39
66	14.27	77	12.23
67	14.06	78	12.08
68	13.85	79	11.92
69	13.65	80	11.77
70	13.46		

This was based on the use of pumping units with an overall efficiency of 70 percent. Let us see what opportunities there would be for effecting savings if we could secure units of higher efficiency. At the same time, for the benefit of the operator who is using units with efficiencies lower than 70, let us see what penalty he is paying. To this end we will examine the costs, (table 4) at our typical plant, of the pumpage of raw and clear water, with a combined total head of 200 feet (30 + 170), with the stated energy rate of 1.5 cents per KWH, but with overall pumping unit efficiencies varying from 60 to 80 percent.

From the figures in table 4 it will be seen that, under the assumed head and energy-price conditions of our typical plant, there is a spread of nearly $4 per million gallons in the pumping costs, over an efficiency range of from 60 to 80 percent. Many a plant is paying dearly for the use of obsolete equipment. Savings effected by its replacement might yield big dividends in public good will, if spent for better purification.

PURIFICATION COSTS

We have seen that at our typical plant the variable operating costs chargeable to purification were less than $5 per million gallons, or 12 percent of the total. When it is further remembered that the total of the plant operating costs is but a small portion of the whole expense

TABLE 5

Comparative delivered costs per million gallons

	DOLLARS	PERCENT
Purification items:		
Alum	2.68	1.34
Carbon	1.40	0.70
Filter washing	0.28	0.14
Ammonia	0.25	0.13
Chlorine	0.23	0.11
All other expenses	195.16	97.58
	$200.00	100.00

of delivering water to the consumer, the fraction alloted to purification sinks into further insignificance. Let us examine this relationship.

The great majority of water systems are municipally owned, and are operated without profit, except such as is necessary to furnish reasonable replacements. Outside of the larger cities, filtered water is seldom retailed under 20 cents per thousand gallons, or $200 per million. From this point the price ranges up to $500 and $600 dollars. These figures may be considered as roughly representing the cost to the respective communities of delivering the water which they sell. If for comparison we adopt the lowest figure—that is, $200 per million—as the cost of furnishing water to the consumer from our typical plant, we then have the relation between the items of purification, as set up, and the total delivery expense shown in table 5.

Thus it is seen that the largest single item of purification cost—alum—is only 1.33 percent of the total delivered cost. Carbon is 0.7 percent, and filter washing, ammonia and chlorine range from about 1/7 to about 1/9 percent. Further, the total purification charges are but 2.42 percent of the whole cost.

In conclusion, it has been the object of this paper to suggest a rational point of view for scrutinizing plant expenditures dealing with purification. While careful thought was given to the selection of the assumed typical operating conditions, these will, of course, vary widely in individual cases. Exact comparisons can only be reached by substituting cost data peculiar to the plant being studied.

(Presented before the Illinois Section meeting, April 20, 1933.)

PROCEDURE FOR MAKING ODOR DETERMINATIONS

By Oscar Gullans

(Senior Sanitary Chemist, Bureau of Engineering, Department of Public Works, Chicago, Ill.)

Increased interest in the prevention and removal of objectionable tastes and odors, and in the use of activated carbons to improve public water supplies in the last two or three years has brought forth several suggestions to improve the method for making odor tests. Most of us are familiar with the method in evaluating tastes and odors given in the last issue of Standard Methods of the A. P. H. A. It was probably the best available at that time, but it falls far short of our present needs.

Spaulding, in 1931, suggested that dilution with odor-free water to find the "threshold point" would give results on a more quantitative basis. In a later publication, August, 1932, he suggests that the intensity of the odor or taste be defined in accordance with the dilution required at the "threshold point."

"Standard Methods" recommends that the intensity of the odors present be evaluated by numbers according to their intensity. Number 0 signifies no odor perceptible, No. 1 very faint, No. 2 faint, No. 3 distinct, No. 4 decided and No. 5 very strong. The procedure recommended for the cold odor test is that the sample be shaken vigorously in the collecting bottle or flask when it is about half or two-thirds full, the stopper removed and the odor smelled at the mouth of the bottle. For the hot odor test, it recommends that about 150 cc. be placed in a 500 cc. Erlenmeyer flask, covered with a well fitting watch glass, heated almost to boiling on a hot plate, cooled for five minutes, shaken with a rotary motion, the watch glass slipped off and the odor smelled at the mouth of the flask. This procedure allows considerable mixture of the surrounding air with the air from the flask containing the odor when it is being drawn into the nostrils. In our laboratory, using this method, we have found the "human" equation to be a big factor in the test, with only a very approximate uniformity in results obtained by 5 or 6 persons on the same sample.

Spaulding's "threshold point" method is a great improvement, in that it places the test on a more quantitative basis. The threshold point is defined as the numerical value of the dilution at which no odor is perceptible. For instance, a sample requiring a dilution of 1 to 10, or ten times the original volume, would be given an odor intensity of 10. The dilutions are made with odor free water and tested in the same way as that recommended in Standard Methods for the hot odor test.

The main trouble with present methods of odor determinations is that the individual making the test frequently does not detect odors that are later detected by the consumer. We suggest, therefore, a combination of the two methods outlined above to include the merits of each, with some modifications, to give more exact determinations and to eliminate the human equation as far as possible.

PROCEDURE

Dilution water. The dilution water must necessarily be clear and free from any taste or odor. It is preferable to prepare it from the local water supply where the test is to be made, if possible, as the diluting water should contain approximately the same amount of dissolved mineral constituents as the water to be tested. The water may be prepared by passing clear tap water or filtered water through a bed of granular activated carbon, or by adding an excess of powdered activated carbon to the water in a large bottle, shaking thoroughly for one-half to one hour and filtering to remove the carbon. We have used a pyrex glass tube, 5 feet long and about 2 inches in diameter filled to a depth of 4 feet with granular activated carbon of $\frac{1}{4}$- to $\frac{1}{8}$-inch size as a filter unit. The regular filtered water from the filter plant effluent is run through the unit to produce odor free water.

The carbon when first placed in the unit should be well washed by backwashing if possible for several hours. Just before using the carbon unit each day, pass through enough water to flush out the water left standing in contact with the carbon. Clean hard glass bottles which have been stored full of odor free water at least 24 hours before being used should be emptied, rinsed with odor free water and then used to collect the odor free dilution water from the carbon unit. We have found two liter Erlenmeyer flasks to be very good for this purpose. The carbon unit should not be run at a rate to exceed 2 gallons per square foot per minute, and about a one gallon rate seems to give best results over a long period of use. It is ad-

visable always to keep the carbon submerged with water, and the carbon should be changed after one or two months, depending upon how much odor free water it is called upon to produce. We find that about $2\frac{1}{2}$ months is the maximum (8 hours per day) time that our carbon unit can be used before odors are perceptible in its effluent.

If powdered activated carbon is to be used, wash the carbon thoroughly on a filter and apply about 400 to 500 p.p.m. of the dry material. Stir or agitate frequently for about 1 hour and then filter through a well washed filter paper or cotton plug into a clean bottle. In the preparation of any odor free water, care must be taken to prevent absorption of odors from the air, and the water should not be stored more than 24 hours in a dark, cool place.

What is intended in the preparation of taste and odor free water is to have the water entirely free from any compound which will produce taste or odor if present in sufficient concentration. Suppose that 1.0 p.p.m. of some compound will produce a barely detectable odor when a concentration of 0.8 p.p.m. cannot be detected. If the sample to be tested contains 2 p.p.m. of the odor compound, and the dilution water contains 0.8 p.p.m., the threshold point will be found to be at a dilution of about 5; whereas, it would be at 2 if the dilution water were entirely odor free. The importance of having dilution water absolutely free from taste and odor compounds cannot be stressed too strongly, as the success of the dilution method depends almost entirely on its quality. Distilled water also has to be treated with carbon before it can be used, and even then is not believed to be as good as the treated tap water, due to its flat taste.

To assist in making the odor determination and to make the test more accurate, a nose piece has been devised to fit the nose and extend into the flask for testing. This nose piece is made of glass tubing about $\frac{3}{4}$-inch in diameter and 8 inches long. It can readily be made from a broken Nessler tube, shaped in a flame to fit the individual nose. The nose piece has two distinct advantages, in that it prevents dilution from the outside air with the air in the flask, thereby making the test more sensitive and accurate; and also it eliminates interference from odors in the room.

It is advisable always to keep the nose piece clean and immersed in odor free water when not being used. This prevents the absorption of odors by the glass and makes it easy to clean.

Making the determination. The glassware must be very thoroughly cleansed before using. First make a cold and then a hot odor test

on the undiluted sample by placing 250 cc. in a 500 cc. Erlenmeyer flask as suggested in Standard Methods, and record the intensity. A number of 500 cc. Erlenmeyer flasks should be thoroughly cleaned ("Sapolio" makes a very good cleaning agent for pyrex glassware). Just before using they should be thoroughly rinsed with odor free water, and it is advisable to keep them half full of odor free water and covered when not in use. This has a tendency to leach out any odors that may have been absorbed by the flask and keeps out atmospheric odors. Ordinary watch glasses, 2 inches in diameter, are used as covers for the flasks. Ordinary glass stoppers or small inverted beakers can be used, but it is difficult to keep them free from odors.

From the intensity of the odor found by testing the undiluted sample, make an estimate of the probable "threshold points." Prepare dilutions in each flask to a volume of 250 cc. with odor free water to be both greater and less than the predicted "threshold point." For a rapid determination, 5 or 6 dilutions should be made, one being the predicted dilution, two or three less and two greater. For instance, if a dilution of 10 is predicted, dilutions of 6, 8, 10, 12 and 14 are made. A blank of odor free water is also prepared. For the cold odor test, the dilutions should be at a temperature of 17° to 23°C. If the dilution water is kept at 20°C. the temperature will be correct for most of the dilutions in the cold odor test.

Starting with the blank and going from the highest dilution down to the lowest, step by step, test each dilution by shaking vigorously, slip off the watch glass and insert the nose piece to within ½-inch of the surface of the liquid. Draw the air within the flask into the nostrils. In this way the air which has been in close contact with the water will be drawn into the nose with little or no dilution from the surrounding air. Record the intensity of the odor according to the valuations given in "Standard Methods" and also the type of odor, such as "e" for earthy, "M" for musty, etc. If the highest dilution still contains an odor, predict from its odor the approximate threshold point and make up another set of dilutions. At least one dilution should have no perceptible odor and at least 2 should have odors.

The hot odor test is made in much the same way using 250 cc. of the dilution, and heating the sample to 65°–70°C. The best method of heating is a water bath, as it maintains an even temperature, and if all the flasks are placed in the bath at the same time, they will all be very near the same temperature when removed. An extra flask

TABLE 1

Typical odor threshold point determinations

DILUTION	COLD ODOR	HOT ODOR
Raw Lake Water, 68th St. Station, R-1, 3:00 p.m., 10-11-32		
0.0	1-e+g	2-e+g
1-1	1-g	1-e+g
1-2	0-o	1-e+g
1-3	0-o	1-g
1-4	0-o	0-o
Odor threshold number...	2	4
Raw Water, Whiting, Indiana, 10:45 a.m., 9-23-32		
0.0	3-m+o	4-m+o
1-6	2-m+o	3-m+o
1-10	1-m+o	2-m+o
1-14	1-m+o	2-m+o
1-16	0-o	1-m+o
1-20	0-o	1-m+o
1-30	0-o	1-m+o
1-35	0-o	1-m+o
1-40	0-o	0-o
Odor threshold number...	15	36
Oil refinery outfall sewer, 1-31-33		
1-1,000	5-o+S	(5+) -o+S
1-10,000	3-o+S	5-o+S
1-100,000	2-o+S	3-o+S
1-200,000	1-o+S	2-o+S
1-300,000	1-o+S	2-o+S
1-350,000	0-o	2-o+S
1-500,000	0-o	1-o+S
1-800,000	0-o	1-o+S
1-900,000	0-o	1-o+S
1-1,000,000	0-o	0-o
Odor threshold number...	310,000	910,000

Symbols: e, earthy; m, musty; o, oily; g, grassy; S, sulphide.

with 250 cc. of water and a thermometer inserted will serve to indicate when the flasks have reached the proper temperature. The

water should be deep enough in the bath to just cover the depth of water in the flasks. A hot plate can be used if the flasks are so placed to reach the proper temperature in the same length of time. A good blank is also necessary heated to the same temperature as the samples.

When making the hot odor test, shake vigorously and use the nose piece as previously directed. It is advisable to smell the blank after each dilution flask has been tested, as it serves to intensify the sense of smell, for it quickly becomes fatigued in the hot odor test. It is always better to wait 5 or 10 minutes between each series of hot odor tests. Since this is just about the time rquired to make up the dilutions and make the cold odor test, no time is lost. Most odors require twice to three times the dilution of the cold odor test to reach the hot odor threshold point.

Occasionally certain odor producing compounds will be found present that do not follow the general trend or relationship between the cold and hot threshold points. For instance, some sulphide odors have a tendency to disappear when heated above 60°C., and other compounds such as sugar beet wastes, require heating nearly to the boiling point and subsequent cooling to bring out the maximum hot odor when present in very small amounts. It is advisable when the samples are heated above 70°C. to make sure they have cooled below that temperature before using the nose piece for the odor test, or the nose will be scalded with steam and it will be impossible to make accurate odor tests for a day or two.

When the samples have high concentrations of odor producing compounds, such as trade wastes and sewage, it is advisable to make a preliminary test to establish the probable threshold point. This is done by making dilutions of 1–100, 1–1000, 1–10,000, etc. to establish the point at which no door is perceptible and eliminate a great deal of work in trying to find the threshold point. For example, if an odor of 2-m was detected at a dilution of 1–1000 and no odor at 1–10,000, it is apparent that the threshold point lies between these two points and dilutions of 1–2,000, 1–3,000, 1–4,000, 1–5,000, 1–6,000, etc., can be used to establish the threshold point.

In many cases where the sample contains only a very faint or doubtful odor, it may be advisable to use a double flask. Fill a 500 cc. flask nearly full of the water or dilutions to be tested, and place an empty 500 cc. flask on the top, attaching them together by means of corks and glass tubing as shown. By inverting the flasks so that

the full one will be on the top, the water will run into the lower flask and when they are both half full, tilt them on the side and shake vigorously for about 10 seconds. Then set the flasks back on end so that all the water will run into the lower flask, remove the upper one with stoppers attached. When ready to make the odor test, remove the stopper and insert the nose piece, drawing the air within the flask into the nostrils. In this manner air which has been in close contact with the sample will first be drawn into the nose with little or no dilution from the outside air.

To avoid excessive squirting of the water from the flasks when using this method for the hot odor tests, both flasks should be heated to the same temperature. This test requires a little more time and is not very suitable where a great number of tests are to be made, but its accuracy more than warrants the time spent in making the test this way when found necessary.

For our tabulations and summary reports we have selected as the "threshold number," a number one greater than the dilution at which the odor was just perceptible. For instance, if the highest dilution in the hot odor test where the odor was detected was at 1–8, the threshold number would be 9. This is done so that we can distinguish the tests where no dilution showed an odor and the 1–1 did not, from the tests where there was no odor present in the original sample. According to our recording, the first mentioned sample would have a threshold number of 1 and the second 0.

This test has been of great value to us in showing the relative intensity of the odors present in our raw and treated waters from day to day. It has also been a great help in determining the relative odor reductions in the treatment of waters with active carbons for odor removal. In about one hour's time we can determine in the laboratory the amount of carbon necessary to reduce taste and odors to approximately zero by applying varying amounts of carbon and making odor threshold point determinations.

The taste tests can be made in much the same way as the odor determinations by making dilutions and using the hot and cold test. Of course, care must be taken not to taste samples that are untreated, or where pollution is suspected.

Some typical odor threshold point determinations showing the general range of the odor tests made and the usual relation between the cold and hot odor tests are shown in table 1.

(*Presented before the Illinois Section meeting, April 19, 1933.*)

REFERENCES

SPAULDING, C. H. Quantitative Determinations of Odor in Water. American Journal of Public Health, 21: 1038–9, Sept., 1931.

SPAULDING, C. H. Some Quantitative Odor Determinations. Journal Amer. Water Works Assoc., 24: 1111–8, August, 1932.

BAYLIS, J. R. Procedure for Making Odor and Taste Determinations. Water Works & Sewerage, 79: 425–6, December, 1932.

WATER SOFTENING PLANTS FOR SMALL CITIES

By H. R. Green

(*Consulting Engineer, Cedar Rapids, Iowa*)

The problem of designing water softening works for the small city, so that they will accomplish the desired results, using plants at once easy to finance and simple to operate, offers a field of study worthy of the engineer's attention. Whether the engineer's renumeration on such small projects warrants the expenditure of time required to care properly for the many details is another problem. To be sure, some items of design can be so standardized that they may be applied to future projects; but no general standardization seems possible with safety. Each city has conditions peculiar to itself; each project is an individual problem.

Two elements of design, however, will be found to apply to all small city conditions; namely, the cost must be kept low and operation must be made simple. To accomplish these two objectives, much study may be necessary to scale down conventional items of equipment to fit the capacity and financing requirements of the small municipality. Therefore, the designer must exercise considerable ingenuity, more perhaps than would be required for an orthodox layout of larger size. He must keep in mind that his plant operator may be not particularly well trained or fitted to vary plant operation with fluctuating conditions. Therefore, at every possible point, constant conditions should be provided for. From the engineer's viewpoint, the small city problem is intensely interesting, but it is one in which the satisfaction of accomplishment must make up a large fraction of his remuneration.

THE CITY'S VIEWPOINT

Whether or not the small city should undertake the softening of its water supply requires considerable thought. There is no denying the advantage of a soft water supply. The enthusiasm of consumers for such a commodity after it has been developed seems almost unanimous, but its installation requires a certain capital investment

and equally certain operating costs. If convenience rather than economy to consumers is the only visible result of these costs, then the plant must be classified as a luxury, and luxuries payable from the public purse are not too popular during the present periodic exchange of ideas on public economy.

It is quite easy to demonstrate on strictly conservative grounds that the soap saving to consumers by reason of reducing a 20-grain water to 4 or 5 grains of hardness, will not only compensate for the capital and operating expense of the softening plant, but will save the consumer most, if indeed not all, of his yearly water bill. This has been proven frequently despite the fact that the city has to soften *all* the water distributed in order that the small quantity actually needing softening by the consumer may be ready for delivery to him. In other words, the city has to soften 50 to 80 gallons per capita per day with its municipal plant, whereas the consumer only "breaks" 2 or 3 gallons per capita per day with soap for laundry, culinary and bathing purposes.

As an actual example, take an Iowa city of 6,000 population using an average of 77 gallons per capita per day, or a total of 462,000 gallons per day. The water drawn from relatively shallow wells has the following analysis:

	Parts per million of $CaCO_3$	*Grains per gallon*
Alkalinity	405	23.8
Non-carbonate hardness	0	0
Total hardness	296	17.4
Sodium bicarbonate	109	6.4
Magnesium (Mg)	31	1.8
Iron (Fe)	3.2	0.2
Free CO_2	12	0.7

After aeration and filtration, 0.49 p.p.m. of iron is left in water.

Based on previously published municipal surveys, the operating cost comparison is about as follows:

The cost of softening this water with a municipal plant from 17 down to 3 grains of hardness, using excess lime and recarbonation method, would approximate 2.8 cents per 1,000 gallons, or a daily cost of softening the 77 gallons used by each person of	$0.00215
The cost of softening the total supply of each person for a year would be	0.788

Assume the average requirement for soft water for each person per day, in gallons	1.2
The required reduction in hardness in parts per million is	238
The soap required is 0.2 pounds per 1,000 gallons per part per million of hardness reduction. This amounts to 47.6 pounds per 1,000 gallons, or an amount of soap required to soften 1.2 gallons per capita per day, in pounds	0.057
Assuming a cost of soap of 12 cents per pound, the daily cost per person to soften the water actually required in household uses would be	$0.00685
The cost of soap per year per person should approximate	$2.47
Now deduct the cost of softening 77 gallons per day per person for one year	0.79
The saving per capita in this case for a one-year period would approximate	$1.68
Assuming an average of four persons per connection, the yearly saving per consumer would be	$6.72
Applying these figures to the population (6,000) the gross saving would therefore approximate per year	$10,080.00
The cost of constructing the complete softening plant for the above conditions, using present day construction and machinery costs is approximately	$35,000.00
Or a capital cost per capita of	5.83
Or a capital cost per consumer of	23.32

It is apparent, therefore, that even in this border-line case, the annual saving to the community is amply sufficient to finance the interest and principal retirement charges and would retire the total funded obligation in a very short period of years.

CONSUMER, NOT THE DEPARTMENT, PROFITS

Unfortunately, however, the apparent handsome economies enjoyed by the community do not appear on the books of the water department as increased income. The only new items appearing on the ledger are a substantial increase in the cost of operation of the municipal water department and the necessity of retiring interest and principal of a new funded obligation.

The obvious answer to the above financial situation is that if the city saves the consumer $6.72 per year, the consumer should not object to having his water rentals increased $2.72 per year, thereby leaving him a personal profit of $4.00 and assisting in retiring the capital expenditure of the city in slightly more than a ten-year period.

But the public seldom takes an unbiased view when utility rates are under consideration. An increase in rentals, be it ever so slight, does not tend to popularize the improvement which causes it, regardless of the benefits accruing to the consumer.

There is one possibility of additional revenues other than an increase in rates. In municipal water works systems where conditions are at all acute or distasteful a distinct reduction in consumption per capita is evidenced. Private wells and cisterns with their potential dangers come into popular use. An improvement in the quality of water delivered to the consumer is bound to have the effect of increasing the consumption per capita without a proportional increase in operating costs. This item of additional revenue cannot definitely be forecast, but there is little doubt that it exists and has a beneficial effect on the department's balance sheet.

Apparently the greatest influence leading small cities to give serious consideration to the installation of softening plants is not necessarily a demand on the part of the public for softer water, but for an improvement in the condition of mains and service lines, and in the appearance, taste and odor of the delivered water. This demand for improvement has become rather general during the past year or two because of the cumulative effect of a relatively high iron content, sometimes accompanied by manganese, present in the water for a period of years but recently more troublesome. Possibly, the exceptionally low precipitation rate of 1930 and 1931 with the consequent lowering of water tables near municipal wells, which during that same dry period were pumped at higher rates than usual, is responsible. Regardless of the cause, there has been a distinct increase in complaints over the State of bad-tasting, bad-smelling waters produced by municipal systems. In some cases at least, this condition is attributable to a growth of so-called iron bacteria in the mains and service lines, together with a collection of evil-smelling sludge in standpipes and mains of low circulation.

Chemical analysis of the water indicates in some cases at least that aeration and sedimentation are not sufficient to lower the iron content below an objectionable point. Where chemical precipitation and filtration are indicated, practically all the equipment necessary for complete softening of the water must be installed. Therefore, we have the peculiar situation of numerous cities and towns being interested in a softened water supply, not because there originally was any particular demand for softer water or any preconceived

notion along that line, but because in order to free the supply from other objectionable influences, substantially the same plant cost must be resorted to. It is fairly safe to estimate that the increased cost for complete softening as against iron removal is only from 10 to 15 per cent.

THE CASE IN IOWA

The 1929 report on Iowa Public Water Supplies issued by the Division of Sanitary Engineering, State Department of Health, indicates that of the 920 incorporated cities and towns in the State of Iowa, 527 have public water supplies. Ninety-two per cent of the urban population of the State are served by public water supplies. These supplies are divided as to source as follows:

284 deep wells
182 shallow wells
19 having both deep and shallow wells
35 surface water supplies
7 depending on springs

These same municipal systems are divided as to treatment as follows:

447 have no treatment
78 chlorinate the water
5 have iron removal
25 have sedimentation with coagulation
21 have rapid sand filters
3 pressure filters, and
3 only soften the water.

To this latter item, some 4 others should be added to bring the report up to date.

The total population now served by soft water supplies approximates 80,000.

Iowa water supplies are hard

It must be kept in mind that compared to waters of the northern and eastern states, all Iowa waters are highly mineralized. The State is deeply covered by drift and soil composed mostly of finely divided material which is highly calcareous and contains considerable amounts of calcium sulphate and other more soluble compounds. The rainfall comes into intimate contact with this material and that

which becomes ground water, from which wells are supplied, must pass long distances through it, giving the water great opportunity to take up mineral matter.

The northeast quarter of the State is usually referred to as the region of lightly mineralized water. The State Geological Survey indicates an average of total solids of 351 p.p.m. in this district, based on 30 deep well analyses. The north central rates at 439, the northwest at 1425, the east central 978, the central 1759, the southeast 1978, and the south central and southwest 3657.

The above average figures apply to wells having a depth in excess of 700 feet. Shallow wells in the hard water district ordinarily are less mineralized than the deep wells, while the reverse is true in the soft water district. Inasmuch as the great percentage of municipal water supplies is drawn from wells of one type or the other, it is safe to say that the great majority exceed 20 grains per gallon of hardness and could be economically improved by ordinary softening processes. There are numerous locations, however, where it is very doubtful whether any small city could afford to soften the municipal supply in the ordinary sense of the term, if in fact an acceptable water could be produced by such process. Well waters, high in sulfates, having 50, 60 and even 80 grains per gallon are frequently encountered. Even when the doubtful cases are eliminated, a large field still remains for this operation where real and economical benefits can be obtained.

THE SMALL CITY PLANT

The greatest hurdle which the engineer accustomed to large water softening installations must take in approaching the small city problem is to realize the change in ratios existing between various factors of design control as compared with the large municipal installations. Take for example a city of 2,000 population, the pumping records of which indicate that 70 gallons per capita per day is the maximum demand. So far as domestic consumption is concerned, this would require 140,000 gallons per day. Obviously, the lowest first-cost plant to produce this quantity would be one which would operate 24 hours a day, or at the rate of approximately 100 gallons per minute. At this point, the question of fire protection must be introduced. As a minimum requirement, assume that $\frac{3}{4}$-inch nozzles operating at 40 pounds pressure at the base of the play pipe are standard equipment in the town, and that two of these nozzles will

be required for a 5-hour period. The total water consumed would approximate 212 gallons per minute, or something over 63,000 gallons for the period. This quantity of production must be provided in the design of the plant, unless it is possible to by-pass the raw water supply safely during a conflagration. Assuming that the water must be treated, this fire protection reserve added to the maximum domestic consumption would bring the total requirement up to 203,000 gallons per day, or a constant rate of 140 gallons per minute. Therefore, with the plant operating at this rate, the domestic consumption requirement could be produced in 16.6 hours of operation.

This 16-hour period of operation is too long for one employee to handle. Therefore two shifts would have to be arranged. If it is assumed that the only additional cost by reason of two-shift operation is the salary of the operator, and that this would amount to $1,000 per year, consideration must be given to the fact that this annual expenditure would pay five per cent interest upon and retire a principal amount of $12,500 over the 20-year legal financing period under which the city must work. It would be economy therefore, to design the plant for a maximum expected domestic consumption on the basis of a 12-hour daily operation period. This would raise the rated capacity of the plant to 200 gallons per minute in order to produce the 140,000 gallons of daily consumption in a 12-hour period. The possible 24-hour operating period would provide an ample factor of safety for fire protection purposes.

Another element prohibiting the scaling down of the plant to a 24-hour continous operation to produce the required domestic load is the shortage of elevated storage capacity usually discovered upon investigating conditions in the smaller cities. Far too often this storage capacity at a usable elevation is too small to carry over the peak domestic consumption period and still allow an adequate fire protection reserve.

Still another element which indicates the inadvisability of designing a plant which must operate 24 hours a day to produce domestic and fire protection requirements combined is the fact that in the small units, the cost of duplicating certain major items is prohibitive, and therefore the plant must be laid out of operation for a period of hours sufficient to complete ordinary maintenance and repairs.

None of the above items of influence run parallel with the requirements or conditions in larger municipal plants. The ratio of fire protection to domestic requirements in the latter case is very much

smaller. Unit construction usually provides for adequate duplication of equipment. In larger installations 24-hour operation is a real economy. All these things tend to keep the cost per capita of the plant lower as the population increases.

COST OF CONSTRUCTION

The consumption of water per capita in larger cities is normally one and one-half or more times as much as in smaller communities. Despite this fact, the economies of design possible in the larger installations more than offset the advantage thus gained by the small towns.

If it be assumed that a complete large city plant can be constructed on the basis of $40,000 per million gallons per day capacity, and that the water consumption per capita, taking into consideration industrial and commercial requirements, is 100 gallons per day, a $40,000 investment will provide for 10,000 population, or a cost per capita of $4.00. In the case of the smaller communities, this base estimating price would probably rise to $60,000 per million gallons capacity. If the per capita requirement is 60 gallons per day, then a million gallon plant would provide for a 16,666 population, or a per capita cost of $3.60. But the above comparison is made on the basis of 24-hour operation, which probably could not be put into effect with any economy. If the 12-hour operating schedule is adopted, the effect is to double the required capacity per capita with a like-increase in construction costs, making the estimated expense $7.20 per capita.

While the above comparison of costs is purely illustrative it does give a fair idea of existing conditions. The latter unit cost estimate should hold good at the present time for a population of approximately 4,000. For populations over that amount, the unit cost should be decreased and the reverse would be true in smaller communities.

FINANCING

In Iowa, works of this nature may be financed in three ways.

(1) Surplus funds available in the water fund may be so used on vote of the City Council or balances in other funds may be transferred to the water fund with the permission of the State Budget Director. No popular election is required. In applying this direct payment method the total income anticipated for the fiscal year (water fund) may be pledged and 6 per cent warrants issued.

(2) Five per cent Water Fund Bonds retired serially over not more than 20 years may be issued after a favorable popular election. The total of bonds outstanding at any time must not exceed the statutory limit of 5 per cent of the taxable value of real and personal property in the city.

(3) The earnings of the water department may be pledged, with the plant as security, and certificates of indebtedness may be issued to the full amount of cost. These certificates are *not* a general *obligation* and can not be retired by millage levy taxes.

(*Presented before the Missouri Valley Section meeting, October 26, 1932.*)

CHLAMYDOMONAS IN STORAGE RESERVOIRS

By Stanley Thomas and J. Wendell Burger

(From the Laboratory of Bacteriology, Lehigh University, Bethlehem, Pa.)

During the summer of 1932 the storage reservoirs of the Lehigh Water Company, which supplies Easton, Pennsylvania, were continuously troubled with growths of Chlamydomonas.

Although of no sanitary significance, the growths were, at times, so heavy that the water became decidedly objectionable to users. Numerous complaints were received from consumers, beginning about the first week in April and continuing off and on until the early part of November. Many of these complaints were due to an unpleasant taste and odor present in the raw water. This ever-present taste and odor, which we have called—with no originality—the Delaware River taste, will be discussed elsewhere. However, complaints regarding a green color and turbidity of the tap water, a green ring or sediment in a glass of water which had, for example, stood overnight by a bedside, a greenish scum on boiled water used in cooking, a sediment in pots and pans, and occasionally of a grassy odor were definitely traceable to the reservoirs. One of the most embarrassing complaints came from a beauty parlor where a ring of green scum was formed in white enamel bowls used for heating water.

The Lehigh Water Company supplies the city with unfiltered[1] Delaware River water, purified by chloramine treatment. The pumping station is off the Pennsylvania bank on the northern outskirts of the city, approximately a mile above the junction of the Lehigh River with the Delaware River.

The distribution system centers in four reservoirs. The water is lifted from the river into two reservoirs situated about a mile northeast of the river on the side of Paxinosa Mountain. These main reservoirs are in tandem, with a combined capacity of 13

[1] A modern filtration plant is under construction and will be in use early in 1933.

million gallons. They are at an elevation of approximately 250 feet above the river. A third reservoir of 800,000 gallons capacity is situated about 100 feet above the main reservoirs. This supplies a small residential community on the opposite side of the hill. The water is pumped to this reservoir from the two main reservoirs. A fourth reservoir of 4.3 million gallons capacity supplies the western section of the city. This basin also receives its water from the main reservoirs on Paxinosa Mountain. The total reservoir capacity is 18 million gallons. As the daily consumption is between 2 and 3 million gallons, the reservoirs hold about one week's supply.

The water from the Delaware River is, in general, quite satisfactory. There is no industrial pollution. The turbidity throughout the year averaged 10–15 p.p.m. The total hardness was low, averaging 30–50 p.p.m. Alkalinity was low, 14 p.p.m. The color seldom reached a maximum of 10 p.p.m. Organic matter calculated from volatile residue averaged 15 p.p.m. The total bacterial count averaged 3000 per c.c. with a B. coli index of 10. On rare occasions the B. coli index rose to 1000, and in many cases was as low as 1.

During the past summer the river was unusually low and there were enormous growths of Cladophora, Spirogyra, Elodea and other water weeds. This resulted in low CO_2 content, and a high pH. On bright, sunny days a pH of 8.8 was not unusual.

Microscopic examination of the river water showed consistently a wide variety of microörganisms. The numbers, however, were quite low. The following is a typical condensed analysis:

	per cc.	*Standard units per cc.*
Diatomaceae	16	44
Chlorophyceae	21	40
Cyanophyceae	0.5	3
Protozoa	3	6
Amorphous matter		350
Totals	40.5	443

These organisms were distributed through more than 50 genera. In spite of chlorination and copper sulphate treatment, 21 of these genera persisted in the reservoir water. Chlamydomonas was found constantly in the raw river water in numbers from 0.5–6.5 per c.c.

In the reservoirs the highest number of organisms other than Chlamydomonas was 125 diatoms and 22 Chlorophyceae per c.c.

Normally the reservoir count was much lower, an average sample showing:

	per cc.	Standard units per cc.
Scenedesmus	8	8
Ankistrodesmus	1	12
Coelastrum	1	1
Pediastrum	1	3
Selenastrum	1	0.3
Closterium	1	5
Navicula	3	3
Synedra	2	2.5
Cyclotella	1	1
Cocconeis	1	1
Amphora	1	1.5
	21	

Protozoans were never numerous: the greatest number, consisting of Chilodon, Vorticella, and Actinophrys, appeared with the aging of the first marked growth of Chlamydomonas.

During the entire period of observation, between April and November, none of the forms with the exception of Chlamydomonas occurred in numbers sufficiently high to make the water physically or aesthetically objectionable.

Chlamydomonas appeared in the reservoirs early in April, but not until the final week of May was its presence macroscopically noticeable. It very evidently entered from the river as it was regularly found in the river during the entire period of investigation.

The genus Chlamydomonas is one of a group of phytoflagellates. It was first described by Ehrenberg[2] in 1838. It may have been first seen by Harris[3] in London 1696, and by van Leeuwenhoek[4] at Delft in 1701. The organism has received considerable attention from botanists, there being about 150 recorded species. Sanitarians, however, have given it scant notice.

The first record of any taste or odor attributable to Chlamydomonas was made by Ehrenberg, who writes: "especially striking

[2] Ehrenberg, Christian G.: Die Infusions Thierchens, 1838.

[3] Ehrenberg, ibid., p. 65.

[4] Ehrenberg, ibid., p. 65.

Dobell, C.: Antony van Leeuwenhoek and his "Little Animalcules," New York, 1932, p. 268.

concerning these animalcules is the 'spermatische' odor which the water has, wherein they live in countless numbers." In 1899, Hollis and Parker[5] described an organism as Chlamydomonas which imparted an unpleasant odor and taste to a natural impounding reservoir. From their description, however, it is questionable as to whether their identification was valid.

Thus it is not entirely clear whether Chlamydomonas can or can not produce a taste and odor. We have found that a flask containing a concentrate of the organism will yield a grassy odor. This is quite intensified by boiling. This odor may be gotten from reservoir walls coated with Chlamydomonas, exposed by a recession of the water. However, in the water, even with organisms present in numbers of 30,700 per c.c., no taste or odor that could be laid to Chlamydomonas was found. This latter observation is in accord with Whipple,[6] who does not list it as causing taste or odor. But Whipple goes further. He lists it among those organisms "occasionally observed," and not giving trouble in water supplies "either by producing odors, or by making the water turbid, and unsuitable for laundry purposes."

The first growth of Chlamydomonas which was apparent in the reservoirs occurred in the last week of May. All reservoirs were affected. Large patches of the water were colored a bright green. Analysis showed Chlamydomonas in practically pure culture, a large motile form, 30 microns in diameter, having the characteristics of the genus.

This form (30 microns in diameter) changed gradually during the last week in May to one 15 microns in diameter, having all the characters of the 30 micron type except for size.

These two types were, from this time on, though persistent, of no numerical significance. They never occurred in numbers greater than 20 per c.c. In their place appeared a still smaller type, 6 microns or under in diameter. The change from 15 microns to 6 microns was remarkably abrupt, being so complete that at first the relationship between these two types was not apparent. However, later observations definitely showed the 15 micron type dividing

[5] Hollis, F. S. and Parker, H. N.: Chlamydomonas in Spot Pond; Jour. New Eng. Water Works Assoc., Vol. 24 (1899–1900), p. 26.

[6] Whipple, G. C.: The Microscopy of Drinking Water; New York, 4th edition, 1927, pp. 248–250.

into the 6 micron form. Another feature causing confusion was the apparent lack of motility of this small form. Biflagellar movement was subsequently found and continually observed, although usually the bulk of the organisms at any one time were motionless.

Despite the observation that the 6 micron type was observed dividing from the 15 micron type, the abrupt transition and the rather exclusive presence of the 6 micron form may lead to a doubt as to whether there was not a second organism appearing. The abruptness of the transition may be due to the fact that our samples were not representative. However, observations on Chlamydomonas (of another species) in various aquaria in our laboratory have repeatedly shown all three types mentioned dividing from each other in a single matrix.

The 6 micron form was quite variable in shape, particularly in the spring, or in the fall when the temperature of the water was around 50°F. While normally oval, it may occur as spindle, cigar, or crescent shaped. These bizarre shapes may have been caused by unfavorable temperature conditions, and possibly, to some extent, by the chemical treatment of the water.

Type of growth of the small form in the reservoirs was twofold. At times the walls of the reservoir became covered with a green, gelatinous mass, which could be scraped off either as light fragile masses, or heavier gelatinous blobs. The walls could be heavily covered while the water itself was not effected to any great extent. At other times the cells, free of envelopes, motile or immotile, were dispersed throughout the water. This sort of growth usually followed heavy wall coats, although at times preceded or was coincident with wall growth. When dispersed in the water, several cells may be found together, inclosed within an envelope.

The organism is able to withstand a considerable range of temperature. It was present in troublesome numbers in the spring when the temperature was below 60°F. and was still present in late November with the water at 40°F. No correlation could be shown by plotting periods of growth against temperature. Nor did there seem to be any relationship between the extent of growth and sunshine. Growth occurred rapidly during a prolonged period of cloudiness. The organism is remarkable for its persistence over long periods of time in great numbers. This same condition was also found in Chlamydomonas living in laboratory aquaria.

TREATMENT

The use of copper sulphate was started June 23 when the numbers of Chlamydomonas in the main reservoirs rose to 12,000 organisms per c.c. An initial dose of 2.75 pounds per million gallons was added by means of a solution feed apparatus at the pumping station. The effect was slight. Though rapid multiplication was temporarily checked, no marked diminution in numbers occurred. About the middle of August with a rapid rise to 30,700 per c.c., the $CuSO_4$ dosage was increased at the pumping station to 5.5 pounds per million gallons. At the same time, 5 additional pounds per million gallons were added directly to the reservoirs. This treatment of 10.5 pounds per million gallons was effective. From this time on for nearly a month, 5.5 pounds apparently checked growth. But, by the middle of September, the count again rapidly rose to 22,800. It was necessary to again add 3 pounds per million gallons (total 8.8 pounds per million gallons) to the reservoirs.

The smaller distributing reservoirs which received their water from the two main reservoirs were also affected by the same growth, and their condition depended largely on that of the main reservoirs. $CuSO_4$ was added in the same proportion here, with approximately the same results.

From these results it is clear that Chlamydomonas will tolerate at least 6 pounds per million gallons, but will yield slowly to 7 or 8 pounds per million gallons.

In one of the earliest papers advocating the use of copper sulphate as an algicide, Moore and Kellerman[7] recommended that this chemical be applied in the proportion of 1 part per million (8.4 pounds per million gallons) to destroy Chlamydomonas.

Later Hale assembled a table, based largely on Kellerman's figures, which showed what he considered the amount of copper sulphate required for the eradication of different microscopic organisms. In this table Chlamydomonas is indicated as requiring 0.5 p.p.m. (4.2 pounds per million gallons). This table was copied by Whipple in the third edition (1914) of his "The Microscopy of Drinking Water" and carried over in the fourth edition.[6] The

[7] Moore, G. T. and Kellerman, K. F.: Copper as an Algicide and Disinfectant in Water Supplies. U. S. Dept. of Agric., Bureau of Plant Industry, Bull. 76, April 3, 1905.

same table is quoted in the Manual of American Water Works Practice,[8] by Hale[9] (1930), by Buswell,[10] and by Hopkins[11] in 1932. It seems clear from our results that this figure is far too low, and that Kellerman's original estimate was more nearly correct.

The factors which are supposed to favor the action of the salt were present in the reservoir water. The amount of organic matter present was low. Total hardness was low. Temperature was high. Alkalinity was low.

The question may be raised as to whether mixing was perfect. Hale has emphasized the fact that the required amount of salt cannot be added in fractions. As the reservoirs are small, and about one half of the copper sulphate was added at the pumping station, where mixing is assured, the diffusion of the other half should be sufficiently thorough. There was no appreciable loss of $CuSO_4$ in the mile of pipe from the pumping station.[12] That the algicide was not entirely precipitated in the reservoirs was repeatedly demonstrated.

After a dosage of 10.5 pounds per million gallons (5.5 pounds at the pumping station and 5 pounds directly into the reservoirs) the direct effluent from the reservoir at the gate house only a few feet away showed 0.4 p.p.m.[13] (3.4 pounds per million gallons). With the normal dosage of 5.5 pounds per million gallons at the pumping station, the water in the distributing system a mile from the reservoir showed from 0.2–0.3 p.p.m. Early in July when only 2.75 pounds were added, the taps showed copper sulphate present in 0.1 p.p.m. The drop was roughly proportional to dosage as would be expected. No difference was to be found between gate house water and that in the distributing system a mile from the gate house.

The drop in copper took place in the reservoir. Analysis of the

[8] Manual of American Water Works Practice, Wolman, A.: Baltimore, 1929, pp. 168–169.

[9] Hale, F. E.: Control of Microscopic Organisms in Public Water Supplies; Jour. New Eng. Water Works Assoc., Vol. 44, No. 3, 1930.

[10] Buswell, A. M.: The Chemistry of Water and Sewage Treatment; New York, 1928, p. 151.

[11] Hopkins, E. S.: Water Purification Control; Baltimore, 1932.

[12] Buswell has incorrectly quoted Hale and Muer in saying all the copper is deposited in iron pipes of distribution system. (Buswell: Chemistry of Water and Sewage Treatment, p. 151, quoting from Engineering Contractor, Vol. 65, p. 66.)

[13] For these and other chemical analyses, we are indebted to Dr. J. Hunt Wilson, Professor of Chemistry, Lafayette College.

sediment on the bottom of the reservoir as late as one and a half months after $CuSO_4$ treatment was discontinued showed copper as Cu in the dried mud in amounts as high as 0.3 percent. As this mud had been receiving a constant increment of precipitable solids from the river, the figure obtained is certainly high enough to indicate clearly the place of copper precipitation.

Chlamydomonas in the storage reservoirs caused three distinct kinds of trouble: first, by its own growth; second, by the turbidity it gave the water when it was killed; and, third, by its consumption of chlorine and resultant aftergrowths of bacteria.

This organism, as previously observed by others, produces no pronounced characteristic taste. When present in great numbers a grassy odor is to be noticed at times. However, its presence does have a slight supplementary effect on the river taste, either giving it a slightly sweetish turn, or intensifying the earthy-musty taste of the river. This is noticed especially in the initial flow of water from a tap where organisms have collected overnight.

Yet the taste effects of this organism are negligible. Its chief importance is the unpleasant appearance it gives the water. Even if the organisms are killed, they do not immediately settle out. Moreover, heavy wall coats break up producing most unpleasant particles. Death of the organisms seems for a brief period to increase turbidity.

As the growth increased in the reservoirs, it was necessary to increase the chloramine application in order to get a residual in the tap. The growth and application were remarkably synchronized. At the height of the growth, 30,700 organisms per c.c., it was necessary to apply 10 pounds per million gallons of chlorine in order to get a residual of 0.05 p.p.m. at the gate house.

Obviously enough, as has been advocated repeatedly before, early treatment is desirable and growth should be checked before it is sufficient to cause trouble.

CONCLUSIONS

1. Chlamydomonas can cause serious storage reservoir troubles: (*a*) by unpleasant color and turbidity; (*b*) by increasing the chlorine demand of the water.

2. Chlamydomonas may assume a variety of forms in its life cycle.

3. At times the organism may cling to the reservoir walls and others be dispersed through the water. These growth phases require different forms of treatment.

4. This organism can resist copper sulphate treatment up to 8 pounds per million gallons.

UNDERGROUND WATER IN HUMAN AFFAIRS

By Rufus Mather Bagg

(*Lawrence College, Appleton, Wisc.*)

No planet in our solar system is provided with vast bodies of water like the earth. Clouds form over Jupiter, polar regions on Mars show faint white lines like snow-fields, but none have great oceans like the earth.

When the molten rocks of the earth's crust solidified they must have been covered by a universal ocean with a dense atmosphere above. The distribution of water upon the earth, however, has repeatedly changed through the ages, even after continental evolution, and Appleton has been covered by ancient oceans at least four times. The history of mankind and development of civilization has always been related to the distribution of water. Today water is the major control in location of cities and industrial centers for the power it furnishes as well as for drinking and means must be found to preserve its sanitation and to increase the supply if such places continue expansion.

WATER AS A GEOLOGICAL AGENT

Of all substances water is the first essential of life. Moreover without a rather constant supply all living things save bacteria quickly perish. Water is the only terrestrial substance of universal distribution which occurs in three different physical states, for it is a gas, a liquid, and a solid while still remaining a natural chemical compound.

In gaseous condition it forms invisible vapor in the atmosphere and no matter how much the amount may vary this moisture is never entirely absent even over the most arid desert.[1] Though unseen, water vapor is one of the most important forms which control both weather and climate. It affects atmospheric pressure, modifies tem-

[1] At Batavia, Java, water vapor in the atmosphere is 2.8 percent by volume, in Persia during the rainy season it reaches 4 percent by volume, and in Europe in summer it is as low as 1.3 percent.

perature, and controls humidity. When condensed we see it in the rainbow, the golden-crowned thunderhead, or feel it in torrential rain.

AS A LIQUID

Salt water covers 72 percent of the earth's surface. What is more remarkable is the fact that it is so deep that if all the lands were dumped into the ocean water would cover the entire earth two miles deep, for there are 57 abysses which exceed three miles in depth, some of which cover more than one million square miles of the sea bottom.

Although each year 6,500 cubic miles of fresh water flow into the ocean from rivers we believe that the saltness of the sea is increasing from minerals in solution which remain after evaporation of water. In solid form as snow and ice, water covers over 6,000,000 square miles in continental ice caps, glaciers, and snow fields.[2] Temperature is the controlling factor of the physical state of the simple chemical compound of hydrogen and oxygen we call water (H_2O)[3] which in liquid form we now consider.

AMOUNT OF WATER ON THE EARTH

The amount of water in the atmosphere is sufficient if condensed to cover the globe five inches deep. The volume in the oceans is about 302 million cubic miles, but the third portion of water stored in unseen caverns, fissures and rock openings underground is not as accurately known. Moreover, scientists who have studied the problem do not agree, but a safe estimate is perhaps 100 million cubic miles, or one-third that in the ocean and enough to cover the earth about 100 feet deep.[4] Whatever figure we accept it is truly astonishing how much water is stored in rocks of the earth's crust down to a depth of eight miles. Beyond that it cannot penetrate owing to enormous pressure and high temperatures.

[2] More than 5,000,000 lie around the South Pole, over 700,000 in Greenland out of 827,275 of land surface are likewise deeply buried under eternal ice, while every mountain range of great altitude is capped with snow fields and their canyons filled with glacial ice rivers.

[3] Water is the unit of measuring weight of solids and liquids, standing 1 in the scale, and if a mineral is 3 times as heavy as water we say its specific gravity is 3.0. The earth is 5.65 times as heavy as it would be if composed of water and hence its specific gravity is 5.65.

[4] Slichter, S. C. Water Supply Paper 67, 1902 (3000′). Kemp, J. F. Trans. Amer. Inst. Min. Eng. 1901 (50–100′). Fuller, M. L. Water Supply Paper 160 (96′).

WATER SUPPLIES OF THE UNITED STATES

Houston, Texas, with a population around 300,000 is the largest city in the United States which obtains its water from deep artesian wells, but Oakland, California, Memphis, Tennessee, and San Antonio, Texas, are almost as large, and San Antonio has the largest system of flowing artesian wells of any city in the country. There are nine wells in San Antonio about 800 feet deep, each well flowing several million gallons of excellent water daily from the Edwards limestone. The amount of water consumed daily by 120,000,000 Americans has not been accurately estimated though it is known for all major municipalities.

Out of 191 cities whose population exceeds 50,000, 76 obtain their supply from rivers, 28 from lakes or ponds, 44 from artesian wells, 40 use impounded reservoirs, and three or four take their water directly from underground springs.[5]

The development of municipal water supplies depends upon a number of factors scarcely two of which are alike. For example, cities of great size could never obtain enough water from artesian wells to supply their need. New York city uses 100 million gallons of water daily from wells, but this is only a fraction of what is required for the 13 million inhabitants clustered around this metropolis. Moreover, many underground waters are so salty or high in mineral content that even cattle can scarcely endure the water, and wells in Australia around the desert margin one mile deep have such hot water that it has to be cooled before stock can drink it. The problems are therefore complex and each requires special study for quantity as well as quality are the ultimate controls.

UTILIZATION OF WATER

From the dawn of civilization the human race has been concerned with the recovery of water and its distribution. Ancient Babylonians dug canals along the Euphrates below the original Garden of Eden. The aqueduct of The Augustine Empire[6] is one of the most impressive sights in Rome. Wells are frequently referred to in biblical literature. Man has always found some means

[5] Large Springs in the U. S. Meinzer, O. E, Water Supply Paper 557, 1927.

[6] The first aqueduct to supply Rome was the Aqua Appia built in 312 B.C. (reign of Claudius) and was 11 miles long. A second in 270 B.C. was about 40 miles long and 1080 feet was on arches.

to carry water along distances or to dig for it in the ground near his dwelling place. Antofagasta, Chile, is a city of 50,000 facing the Pacific Ocean from an inland desert, but it exists solely because they have a pipe line 193 miles to the base of the Andes where melting snow yields enough water to supply this sea port where rain never falls in 30 years.

ARTESIAN WATER

The term Artesian is from a Latin word for Artois, northern France, where wells sunk by primitive methods flowed above the surface of the ground. One of these ancient wells at the convent of Lillers has been flowing steadily over 800 years (1,126 A.D.). More recent use of the term came to include any deep well in which the water rose above the ground water level because of pressure or hydrostatic head. Depth is not an essential, but we think of an artesian well as only one of considerable depth whose water column comes near the surface or gushes out above the ground. Technically I should include no well, however, deep, whose water level did not rise above that of the ground water level of the surrounding country. There is no better definition of an Artesian well than this.

What is the record artesian well in the United States? It is probably the Oasis Cotton Company's well drilled in 1931 near Roswell, New Mexico. This well is over 12 inches in diameter and about 900 feet deep and it throws a stream of six inches in diameter from a reduced nipple fifty feet in the air. Its rated volume is 13,284,000 gallons of water every 24 hours.

The strangest well I have ever known in my drilling investigations was one in Milwaukee which I like to call "my ink well." Many years ago an artesian well was drilled for a tanning plant and had been flowing in volume for a long time until a cavity was developed at the bottom of the well at 1,600 feet depth. As the water had become highly mineralized I was called in to find out whether we could not secure softer water from some vein either above or below that already developed. We first drilled 200 feet deeper and to within 300 feet of granite, but when the drill broke through a crust cover at 1600 feet the well flowed black ink for two days to the great surprise of everyone. I knew the Creator never deposited a large body of genuine ink 1600 feet below the surface at Milwaukee. After first proving the fluid to be true ink, for so it analyzed, I sought and found the cause. Close to the casing wall a tannic acid pipe line was located

and during the years had sprung a leak permitting the tanning chemicals to trickle down along the casing well. Since the water ran very high in both iron and lime it had formed this ink (solution) and it had slowly settled down into the cavity at the bottom of the well. This crusted over and thus the ink was preserved until we broke through the cover of the cavern when sinking deeper. In a few days the trouble disappeared.

This study of underground water leads me to digress a moment to consider a question frequently asked me "Can anyone locate water with a 'Divining Rod'"? A belief still widely exists in this method of locating water veins and many persons refuse to be convinced that this is an impossibility and that it is not far removed from Clairvoyancy, or other occult science.

THE DIVINING ROD

The superstition which arose from use of the Divining Rod[7] dates from most ancient time being known to the Medes and Persians in the days of Babylon. In Germany a forked stick was used to locate metal veins, then to discover buried treasure, to cure disease, or to locate fortune, but when tried for water the forked stick of willow, apple, or hazel bush was held downward indicating the presence of the water sought. This application probably goes back to the middle ages when according to Spanish records we read:

> Teresa in 1568 was offered a site for a convent to which there was only one objection—there was no water supply; happily a friar Antonio came up with a twig in his hand, stopped at a certain point, and appeared to be making a sign of the cross; but Teresa says, "Really I cannot be sure if it were the sign he made, at any rate he made some movement with the twig and he said 'Dig just here.' They dug, and lo, a plentiful fount of water gushed forth, excellent for drinking, copious for washing, and it never ran dry."

---

[7] Dr. O. E. Meinzer of the U. S. Geological Survey sums up this matter as follows: "It is by no means true that all persons using a forked twig or some other device for locating water or other mineral are intentional deceivers. Some of them are doubtless of good character and benevolent intentions. However, as anything that can be deeply veiled in mystery affords a good opportunity for swindlers, there can be no reasonable doubt that others who take pay for their "Services" or for the sale of their "instruments" are deliberately defrauding the people, and that the total amount of money they obtain is large," He concludes: "To all inquirers the U. S. Geological Survey therefore gives the advice not to expend any money for the services devised for locating underground water or other minerals."

This water witching or "dowsing" still receives too much recognition and cannot be relied upon as with geologic knowledge of underground conditions.

INDUSTRIAL UTILITY OF WATER

Nothing can be more important about water, whether obtained from surface flow or subterranean sources, than its mineral content which so largely controls its domestic and industrial use. The longer I study water supplies for all sorts of purposes the more impressed I am with the importance of unseen chemical substances dissolved in water, but in most varying amount everywhere. If the mineral content is "high" in iron, lime, and magnesia we say the water is "hard," but if it lathers easily with soap we call it "soft."[8] Rain water falling from the sky is the purest on earth unless it be the melted snow flake which crystallized in feathery hexagonal form. But even rain water has impurities. Every drop of rain has formed around microscopic dust whose diameter in cloud-forming particles is less than one four-thousandth of an inch. These dust particles essential for every rain are however so minute that falling rain is considered pure water and is only exceeded by that distilled in the chemical laboratory. If dust is removed from air and the water vapor condensed by cooling rain drops will not form in the glass tube but cover the sides of the glass like dew.

SUMMARY

It must be evident from the foregoing that water has been and always will be the supreme need of the human race and upon this civilization depends. Water must be conserved more and more as the years go by if man is to attain his largest prosperity and happiness. Dry regions must be supplied with water either through irrigation, storage, or development of artesian wells.[9] The Peruvian Indians

[8] It requires 2 ounces of soap for 100 gallons of water for each grain per gallon of lime carbonate to make it "soft." Hence water of 15 grains per gallon would require 30 ounces of soap to neutralize 100 gallons of such water. In other words one part of lime carbonate requires 8 of soap to neutralize it. Iron makes tannin in tea black.

[9] In riding over the high Karroo of South Africa the plateau looks rich in fertile soils adapted to agriculture. The rainfall here of 20 inches surely looks enough for crop production, but there is one trouble which prevents this, for the rain falls in 30 to 60 days and then the region is dry for months. Wells and storage reservoirs would redeem much of this vast territory covering one million square miles.

are living under most unsanitary conditions but how can you blame them for never washing when water is so scarce?

Forests must be properly distributed and maintained not only to reclaim land, but to prevent violent denudation, while other areas under changing rainfall must be provided with storage reservoirs against periods of extreme aridity.

Streams must be kept more rigidly from contamination. Improved methods of water treatment must be devised especially in regions where high alkalinity and mineral content make the water undesirable. Water supplies have been extensively studied and developed, yet much remains to be done.[10]

New discoveries are still possible which will reduce the cost of water treatment just as those of mining which reduce the cost of mineral extraction. Water is indeed a strange substance, but upon it life depends.

(*Presented before the Wisconsin Section meeting, October 26, 1932.*)

[10] In the U. S. over 17,000,000 people have water below 55 p.p.m. in hardness, 6,000,000 use water from 55 to 100 p.p.m.; 11,000,000 have a supply from 100 to 200 p.p.m., and 4,500,000 are now compelled to use water above 200 parts per million.

THE PLACE OF PUBLIC WORKS IN THE ECONOMIC SCHEME

By Willard T. Chevalier

(*Publishing Director, Engineering News-Record, New York, N. Y.*)

I should like to preface what I have to say on this subject by a reminder that the purpose of any economic system, after all, is to provide employment. We hear much today concerning currency inflation, gold standards, tariffs, international debts, and all the rest, but whatever we may do or refrain from doing with respect to these, the test of the economic system under which we live is whether or not it provides an opportunity for those who are willing to work to earn their living. This is the essential criterion by which any system must be judged.

The method by which men and women are enabled to earn their living is to provide them with an opportunity to exchange the goods and services they produce. The more easily and regularly this exchange is effected, the more opportunity is given to each to do his part in serving the rest of the community and in making his own way. This is the purpose of all industrial and business enterprise.

Some of the goods and services thus produced and exchanged are the concern of private industry. Some of them are the concern of the community. It is a long time since the community occupied itself only with the conduct of government in the strict sense of the term. Once it was engaged only in administering the laws and the police powers of the state and the cost of government included only the cost of this service. Today our communities render many services to their citizens that are essentially economic or social and have nothing to do with their political conduct. It follows, therefore, that much of the so-called cost of government is in effect a charge for value received just as truly as are any of the charges paid by the citizens for the commodities and services produced by private business. In considering the so-called cost of government and community finances, it is most important to bear this fact in mind.

Between the business of private industry and that of the com-

munity, there is one essential difference. The essence of private enterprise is profit. In the ideal case the services rendered by the community are rendered at cost to the consumer.

Profits are necessary to private business not alone because they supply an incentive to progress and encourage men to undertake risk, but also because they provide the capital that is necessary to develop new wants and needs, to replace outworn and obsolete production facilities, and to make possible the provision of additional facilities to produce more goods and new types of goods.

PUBLIC WORKS ARE PRODUCTIVE ENTERPRISES

Right here it is important to note that the production of new capital is the reason why private enterprise frequently is referred to as "productive business," while community services are referred to as non-productive. Because of this, expenditures and investments incurred in behalf of community services are referred to as non-productive expenditures or investments.

This, of course, is an absurd distinction. The provision of a water supply, of educational facilities, of highways, and of other public facilities, is just as productive as are any of the occupations of private business. Indeed, many public facilities are productive not only of a higher standard of living, but are productive also in a pecuniary sense. They may reduce the cost of other types of service, such as fire insurance or health service, or, as in the case of the highways, they may give birth to new industries dependent upon them amounting to billions of dollars, and thereby create new wealth and employment that could not exist without them.

When we refer to private industry as productive, what we really mean is that it is, or should be, *reproductive.* That is to say, it not only produces some addition to our wealth in the form of goods or services, but through the medium of accumulating profits, it tends to reproduce the capital originally invested.

The economic system under which we live operates in general on this reproductive basis. Under it we have made extraordinary advances during the century and a half of our existence as a nation. It is evident, however, that the uncontrolled operation of this system involves periodical fluctuations in employment, in profits, and in the return on capital investment of every sort.

A rapid expansion of private industry brings an upswing to all business, with rising prices, wider employment and greater profits.

The ensuing and inevitable contraction brings a corresponding downswing, with lower prices, less employment and smaller or vanishing profits.

It is our nature to remember only the prosperity of the upswing and although some generations have suffered the inevitable periods of deflation, we seldom remember them when we measure the total progress achieved over a long period of time.

As our industrial civilization becomes more complex, and as more and more of our people are dependent in greater and greater measure upon each other for their livings, it becomes necessary for us to consider seriously the effects of a process of deflation. It is cumulative, leading to loss of confidence, fear and panic, with curtailed purchasing power and increasing unemployment.

Today under the impact of such a deflation, our economic system has broken down until it is estimated that now some twelve million to fifteen million men and women in this country have been thrown out of employment; that is, they are unable to earn their living through the ordinary processes of producing and exchanging goods and services.

WE CANNOT LIQUIDATE HUMAN BEINGS

It will be obvious that when for any reason private industry suffers a contraction in the demand for its goods or services, it must curtail its expenses, for after all, if it is to endure it must meet expenses and maintain a profit. Obviously this curtailment involves the reduction of pay rolls and the discharge of employees, but when for any reason private business no longer can use men and women, *they do not vanish into thin air*. We may write down or liquidate our investment in material things but we cannot liquidate our investment in human souls. These people are still with us and so long as our society is dominated by a humanitarian and social ideal, we shall as a community assume the responsibility for maintaining those of our fellow men who are so unfortunate as to be unemployed by private industry. In other words, when they go off the private payroll they must go on the public payroll.

Now, there are two kinds of public payroll. There is the non-productive payroll known as direct relief or the dole. This payroll is not alone a non-productive payroll, but it is a destructive payroll. While it may for the moment conserve the mere physical existence of those who are on it, it operates inevitably to destroy those intangible

and essential elements that determine the value of a man to himself and to the community of which he is a part. No man can tell me that a normal man or woman can continue indefinitely to live by virtue of charity without its doing something to his or her soul. While it may be necessary in the interest of sheer physical survival for our communities to maintain a certain measure of direct relief, this should be regarded as a last resort to be invoked only when every other resource has failed.

The other public payroll is a productive payroll; that is, it renders some form of useful or productive service to the community. It puts those whose services can no longer be sold through private industry directly to work for the rest of the community, rendering those services normally performed by the community for its citizens.

It will be obvious that both these payrolls must be met by the citizens who still are employed and by all those who contribute to the taxes levied by the community. The only difference is that in the first case, the community gets nothing in return but the gratitude of those it has helped, and in many instances even this is a questionable return. In the other case, the community does get a direct return and furthermore has helped those who receive its relief to preserve their self-respect and their morale.

For three years we have tried to depend almost exclusively upon the non-productive public payroll as the means by which to absorb those who have been unable to find employment in private business. Today it may be said without reservation that this program has been a failure and that a continuing increase in unemployment must soon put an intolerable burden upon our people who still are employed and still have earning power. The rising cost of direct relief is one of the most menacing aspects of the period through which we have been passing and it is time for us to deal effectively with it.

WHERE CAN WE BEST USE THE UNEMPLOYED?

Coming back again to the fundamental question of employment, we find men engaged in two types of productive work. The first has to do with the production of shoes, shirts, hats, food and all other commodities and services that we use up as fast as they are made and that we pay for out of current income. These are the consumable goods and their production and exchange constitute an important part of our industry.

The other type of work involves the production of buildings, loco-

motives, water works, highways, and those structures and facilities that are required to produce the consumable goods and services and to make possible the complicated operation of modern industry, commerce and community life. These are what are known as durable or capital goods.

It is obvious that the community cannot put its unemployed to work in the production of consumable goods. In a time of depression there exists already a surplus capacity for the production of such goods. And if the community were to engage in their production, it would be merely competing with the private business enterprise to which it must look for the earnings and the taxes that make possible the conduct of the community. In other words, it profits nothing for the community to put these people to work at occupations that will compete with the already stagnant private business.

It is equally obvious that it cannot put all these people to work in the rendering of current services which must be paid for by the taxpayer as they are rendered. The income of the taxpayer and the rent payer is reduced, the earnings of private business are curtailed, and the community is asking for a reduction in the cost of its current operations rather than an increase.

So, in order to provide employment on an adequate scale, the community can turn only to the business of providing those durable facilities for community service which are covered by the general term, public works. These being of a durable nature constitute capital investments which may be financed by the use of credit and their cost to the community thereby spread over a period of years to come.

UNEMPLOYED HEAVIEST IN CAPITAL INDUSTRIES

It is doubly important that we find our employment in this direction because of the fact that some 35 to 40 per cent of the employment in normal times is in those industries which produce the materials, machinery and the equipment required for the construction and provision of such capital facilities. In a time like the present, when for many reasons the process of capital investment has been suspended, the burden of unemployment weighs most heavily upon these industries; and anything that may be done to stimulate them strikes most directly at the source of our greatest unemployment.

Such a procedure constitutes not only an aid to those industries that produce this type of materials and equipment, but indirectly is a substantial aid also to the industries that produce consumable

goods. By putting the many unemployed in these basic industries back to work, their purchasing power is restored and they become immediately a larger market for the products of the consumable goods industries and for the trade of Main Street in these products.

PRIVATE ENTERPRISE CANNOT RESUME INVESTMENT

Important as it may be to stimulate capital investment in order that we may bring employment to the industries that produce the basic materials, machinery and equipment, it is evident that we cannot expect private business and private enterprise to undertake such investment. With an excess of capacity in existence and with diminishing earnings, there is no incentive to private industry to undertake expansion. On the other hand, unless the country is going altogether to smash, our communities always will have use, sooner or later, for new public facilities. So the government, with the credit of the nation behind it, is about the only agency that is in position to take the initiative in this essential move to revive capital investment.

If, however, we are going to borrow in order to finance this investment, it is necessary that we balance our current budgets by cutting down to a minimum the demand for revenue to meet current operating expenses. Only by balancing the budget and thus evincing a determination to keep current expenses within current income can the community win and maintain the confidence upon which its credit must be based. This process of curtailing current expenses has been going on for some time past and must be continued if the program of public investment is to be made successful.

Having, then, balanced our current operating budgets and secured our credit for the future, we are able to use that credit to finance capital investment on a large scale and thereby convert it into employment and current purchasing power. Thus we may revive normal employment and stimulate reproductive enterprise and trade, thereby setting in motion forces that will create the incomes, the earnings and the profits required to service the debt incurred and pay it off.

THE PUBLIC WORKS BILL

Such a program is the intent of the Public Works Section of the National Industrial Recovery Act. If it be entered upon courageously and administered intelligently, it will accomplish these purposes:

a. Keep public works employees now on the payrolls and thereby prevent further unemployment.
b. Put back to work many of the people now unemployed.
c. Put back to work many more thousands employed in the mills, factories, quarries, gravel pits and other sources of materials and equipment that go into public works.
d. Revive purchasing power and the demand for consumable goods, which will in turn stimulate private industry of every description.
e. Restore earning capacity and profits to private enterprise, thereby breeding new confidence in the future.
f. Thereby stimulate the will to invest capital on the part of private business and put more and more people back to work in private industry at their normal jobs.

This is the policy now adopted by the government. Fortunately, to carry it out it is not necessary that we engage in any extravagant inflation of our public works activities. Right now because of the suspension of projects during the last couple of years, we are nearly three billions of dollars behind our normal investment in public works, and if we but bring ourselves down to date in this respect we shall be able to make a substantial reduction in the ranks of the unemployed.

A RIGHT AND A LEFT

In considering the National Industrial Recovery Bill, it is important to realize that its two parts must be considered as a unit. Together they constitute one attack on our problem. They are a right and a left. Wielded effectively in cooperation, they can knock out the depression. Otherwise, we must fight it with one hand tied behind us.

The Public Works section is the aggressive or activating part of the measure. It is designed to strike directly at unemployment, to release purchasing power, and to stimulate the capital goods industries upon which depends so much of our general employment and prosperity.

But, if that stimulus is to carry through with a cumulative effect, the Industry Control section is equally necessary. It is designed to stabilize prices, to restore the earning power of private industry and protect employer and employee alike against the destructive effects of the blind, cut-throat competition that has been bred by three

years of panicky deflation. If the public works project is to be fruitful, industry must be put in position to thrive on the employment and purchasing power created by that effort.

We may put it this way: The public works program is the boiler that will generate the pressure required to speed up the business engine; the industry control measure is designed to tighten up the joints in the steam line and to put a governor on the engine so that the power will not leak away and be dissipated through destructive competition and maladjustment.

NOW THE TIME FOR ACTION

We have been through a long period of debate as to the wisdom of this policy. Every argument for and against it has been advanced, considered, accepted or rejected. The time for debate is past. We have made our decision. The duty of everyone now is to do his best to make the adopted program successful.

We must remember that although today there are many signs of business improvement, these are based largely upon hope. Much of the rise in prices and values is speculative in contemplation of higher prices, either artificially created or as the result of genuine improvement. If, however, these speculative advances are to be sustained and if we are not to suffer another relapse, we must support them by a substantial body of real purchasing power. The two must go hand in hand and the increased production stimulated by prospective increase of price and demand must be backed by a purchasing power commensurate with it.

This is the proper moment at which to launch a public works program. It is time to throw in our reserves. The prudent and skillful commander seizes the moment when the first break appears in the enemy's lines to throw in his reserves. Now with an upturn in the hope of our people, and with the rise in prices and values contingent upon that hope, we have our opportunity to throw in the decisive weight of a vast purchasing power and clinch the decision.

THREE OBLIGATIONS OF THE MOMENT

This is the purpose of the present effort. Its success will depend upon how effectively engineers, superintendents, officials and others connected with the administration of our public works, put to work the financial resources now made available.

Specifically, then, we have three obligations:

a. To get our work in hand and to get this money in circulation just as quickly as possible.

b. To insure that the Public Works Program is carried on through normal channels and normal methods. It will not do merely to scatter the present recipients of direct relief promiscuously over construction jobs to put in their time with picks and shovels. Our objective is to put men back to work at their normal occupations, not to perpetuate breadlines thinly disguised as productive payrolls. Specifications must be prepared, contracts let, and men put to work by normal and efficient procedure; thus only can we stimulate employment that will be fruitful and permanent; thus only will the bulk of the unemployed find their way back to the work for which they are best fitted and thereby take their places in the march back to prosperity.

c. Moreover, those who administer the public works section of this measure must be governed by the spirit of the industry control section. They must take care that they themselves do not foster "chiseling" and cut-throat methods. Their specifications must not impose abnormal restrictions that will make for waste and inefficiency. Their contracts must not be awarded at prices that will exploit both employers and workers. They must guard against the evils of bid peddling and all the other abuses against which the industry control measure is directed.

If the Government is going to control industry in the interest of fair competition, it may reasonably be expected to set an example to industry in its administration of the act by which it exercises that control. It can make or break its effort as a lawmaker by its conduct as a buyer in the market place for which it legislates.

This is the need, this is the opportunity, and this is the responsibility. The water works field on many counts is in exceptional position to deal with all of these, and if it will do its part, and if other public works departments will do their parts, there will be good reason to expect a successful outcome of the great program for national recovery of which the new legislation is so vital a part.

(Presented before the Annual Convention, Chicago, June 13, 1933.)

SOCIETY AFFAIRS

THE CANADIAN SECTION

The thirteenth annual convention of the Canadian Section, was held at Ottawa, Ontario, March 22 to 24, 1933. It was one of the best that has yet been held. The registration reached a total of 360, the highest figure the Section has ever reached. Last year a record was established with a figure of 316. Even under present conditions, sufficient interest is manifest in the importance of water works operation to bring out this very large attendance.

The program was a good one, and valuable papers were heard. These papers dealt with a variety of subjects including, Large Concrete Watermains, Treatment of Water for Industrial Purposes, Softening Municipal Supplies, Construction of the New Intake Pipe for the City of Toronto, Public Health Engineering in the Province of Quebec, and two symposia. The first dealt with Methods of Charging for Domestic Water Supply. The second was concerned with the operation of a number of the recently built filtration plants in Canada. An interesting feature at the convention was one session devoted to problems concerning water commissioners. Three papers were given in this session. It proved to be of interest not only to the commissioners, but also to waterworks operators.

The convention was fortunate in having a very fine group of exhibits. These were displayed in the hotel just adjoining the convention room, and practically all materials used in waterworks projects were to be seen.

The delegates had an opportunity to visit the new filtration plant put into service last year by the city of Ottawa, as well as the Hull Waterworks system. They found much of interest in these two plants.

The convention did not lack in entertainment to make it a most enjoyable one for the delegates. Luncheon was served on the opening day and a banquet on the evening of the second. The banquet was marked by an important address on present day problems by the Honourable Dr. R. J. Manion, Minister of Railways and Canals of the Dominion Government. This was followed by the

usual high class entertainment sponsored by the Water Works Equipment Association.

The business session of the convention disposed with a number of important matters. Toronto was chosen as the meeting place for the year 1934. It was also decided that future conventions would continue to be held in the Spring of the year rather than in the Fall. An important committee report was adopted and referred to the executive for action. This dealt with the disposal of surplus waterworks funds from the operation of waterworks systems in Ontario. At present these surplus funds must be turned back to the municipality for general use. Waterworks men have felt that this money should be retained for future needed extensions or alterations to the plants.

Several ladies from out of town were present at the convention and had a most enjoyable time. The local committees had made excellent arrangements and provided enjoyable entertainment for their guests.

The new members elected to the executive are as follows:

Chairman: A. U. Sanderson, Assistant Electrical and Mechanical Engineer, Department of Works, Toronto.

New Trustees: F. P. Adams, City Engineer, Brantford and T. J. Lafrenière, Sanitary Engineer, for the Province of Quebec, Montreal.

Those retiring this year from the executive are: N. J. Howard, Toronto; J. G. Archibald, Woodstock and Theo. Lanctot, Hull.

A. E. Berry,
Secretary.

THE SOUTHEASTERN SECTION

The fifth annual meeting of the Southeastern Section, at Radium Springs Hotel, Albany, Georgia, was attended by 140 water works officials and representatives of waterworks material manufacturers. All technical sessions and the Convention banquet and dance were held in the Radium Springs Casino on April 4, 5 and 6, 1933.

Hon. J. S. Billingslea, Mayor of Albany, and Dr. J. A. Redfearn, Albany, greeted those present and cordially welcomed the Southeastern Section to their city. Beekman C. Little, Secretary of A. W. W. A., gave a brief history of the American Water Works Association and illustrated the aims and work of the Association by naming a few of the prominent engineers and water works men who have been elected to the presidency.

The afternoon of April 4 was devoted to an automobile tour to Thomasville, Georgia. The inspection trip included visits to the municipal power and water softening plant, a commercial filter sand preparation plant and some of the beautiful country estates. The inspecting groups reassembled at the American Legion Home for a complimentary buffet dinner by the Thomasville Water and Light Department.

The morning session on April 5 was a symposium of purification plant and water treatment papers: "Design and Care of Filter Beds," W. M. Wallace and A. B. Morrill, Detroit, Mich., "The Richmond, Virginia, Filter Plant," M. C. Smith, Engineer, Water and Electricity, Richmond, Va., "Adsorption of Copper Sulfate by Alum Floc," Dr. C. J. Brockman, University of Georgia, Athens, Ga., "Ammonia Salts in Water Treatment," A. J. Smalshaf, Superintendent of Filtration, Columbus, Ga., "Removal of Bacterial Flora from Water in the Settling Basin by Added Clay Dispersions," Dr. E. M. Slocum, General Reduction Co., Macon, Ga.

The afternoon session on April 5 included the following papers: "What Cost Obsolescence," L. H. Enslow, Editor, "Water Works and Sewerage," New York City, "Safety of Public Water Supplies," L. M. Clarkson, State Board of Health, Atlanta, Ga., "How Many Accounts Are Necessary for the Practical Application of Mechanical Billing Equipment?" E. A. Kalkurst, Burroughs Adding Machine Co., Detroit, Mich., "Recent Developments in Sewage Treatment Practice," C. A. Emerson, Jr., of Fuller & McClintock, New York City.

An afternoon theater party was given for the visiting ladies.

The Convention banquet and dance in the evening concluded the day's program.

The final technical session on the morning of April 6 carried papers on "The Manufacture of Sulfate of Alumina," R. L. Brown, Paper Makers Chemical Corporation, Atlanta, Ga., and "Relation of Sanitation to Water Works Revenue," H. E. Miller, Special Expert, United States Public Health Service, Washington, D. C. A demonstration of the photo electric cell by J. H. Persons, Research Division, General Electric Co., Atlanta, Ga., and a paper and exhibit showing a newly developed sanitary cotton calking yarn by W. M. Rapp, Superintendent of Distribution, Atlanta Water Works, Atlanta, Ga., concluded the session.

At the business session the following officers were elected for one

year: Chairman, J. K. Marquis, Spartanburg, S. C., Vice Chairman, R. E. Findlay, Macon, Ga., Secretary-Treasurer, W. H. Weir, Atlanta, Ga.

After the adjournment of the Convention, the annual Southeastern Section Golf Tournament was held on the famous Radium Springs Course. Thirty water works superintendents and manufacturers representatives participated in the match.

R. E. FINDLAY,
Secretary-Treasurer.

THE MONTANA SECTION

The eighth annual convention of the Montana Section, was held in Havre on April 21 and 22, 1933. There were 57 registered for the meetings and 75 attended the banquet on Saturday evening.

The high light of the convention was the presence of Mr. George W. Pracy, Superintendent of the San Francisco Water Department, and president of the parent association. His attendance and frequent speaking added very materially to the success of the occasion.

Mr. Wade Plummer, Superintendent of the Butte Water Company, and Chairman of the Montana Section, presided. The principal topics for papers were:

"Copper Pipe for Water Service," Charles W. Towne, Butte, Publicity Director, Anaconda Copper Mining Co.

"The Havre City Water Works," E. Sandquist, City Engineer and Water Superintendent, Havre.

"Public Relations and Delinquencies," Eugene Carroll, Butte, Vice-President and General Manager, Butte Water Co.

"Reconstruction Finance Corporation Loans for Water Works and Sewerage Projects," Francis A. Thomson, Butte, President, Montana State School of Mines, and Advisory Engineer, R. F. C. Helena Office.

"The Utilization of Alkali Waters from the Engineering Standpoint," W. M. Cobleigh, Bozeman, Dean, School of Engineering, Montana State College.

"Ground Water Supplies in Montana," Eugene S. Perry, Butte, Head of the Department of Geology, Montana State School of Mines.

"Advantages of the Automatic Sprinkler System," David Thomas, Engineer, Board of Fire Underwriters, Great Falls.

"Some Interesting Experience with Tastes and Odors in Water," H. B. Foote, State Sanitary Engineer, Helena.

Motion Pictures Depicting the Drilling of Wells and Installation of Pumps. (Courtesy of Layne & Bowler, Inc., Layne-Western Company, Kansas City, Mo.)

The operators' round table discussions were led by J. M. Schmit, City Engineer of Lewistown. The topics and those discussing them were:

"Activated Carbon in the Treatment of Water," F. E. Brandis, Superintendent, Water Department, Chinook.

"Civil Service Regulations for Water Works Departments," A. H. Anderson, Superintendent, Filtration Plant, Great Falls.

"The Water Works Laboratory," F. M. Badger, Operator at City Filter Plant, Billings.

"Underground Waste Detection," J. R. Cortese, Superintendent, Water Department, Livingston.

"Beautifying Water Works Properties," H. S. Thane, Superintendent Missoula.

"Cross Connections with Reference to Plumbing Fixtures," A Demonstration.

The associational program was preceded by a two day water works operators school, which was in charge of W. M. Cobleigh, Dean of the School of Engineering of the State College, Bozeman, and H. B. Foote, Sanitary Engineer of the State Board of Health. Mr. J. W. Forbes, Director of the Food and Drug Division, assisted. 49 registered for this school.

It was brought to the attention of the association that the sewer rental measure which was presented to the state legislature during the past winter was passed and approved by the governor. This provides for the levying of rental charges by municipalities, thereby making sewerage systems self-liquidating.

After passing suitable resolutions the section adjourned, after selecting Billings for the 1934 (Ninth) convention, and after electing Mr. H. S. Thane, Superintendent, Missoula, chairman, Mr. Claude W. Eyer, City Engineer of Glendive, vice-chairman, Mr. F. E. Brandis of Chinook, Superintendent, Water Department, and Mr. Dave Thomas, engineer of the Board of Fire Underwriters, Great Falls, trustees. Mr. H. B. Foote, State Sanitary Engineer, Helena, was reappointed Secretary-Treasurer. Mr. Emil Sandquist, city engineer of Havre, was elected as Director on the National Board to represent the Montana Section.

H. B. Foote,
Secretary-Treasurer.

THE KENTUCKY-TENNESSEE SECTION

The eighth annual meeting of the Kentucky-Tennessee Section was called to order by Chairman H. K. Bell at 10 A.M. Thursday, February 9, 1933, in the Roof Garden of the Brown Hotel, Louisville, Kentucky.

Mr. E. J. Miller, President of the Louisville Water Co., extended welcome in behalf of the City and of his Company. He was responded to by Mr. J. T. Campbell of the J. N. Chester Engineers, Pittsburgh, Pa.

Dr. A. T. McCormack, State Health Officer of Kentucky, in his address emphasized what the waterworks fraternity owed to the late Charles Hermany, Chief Engineer of the Louisville Water Company, and to his associates for the information gained from their experiments in attempting to devise some satisfactory method of treating the Ohio River water. He further urged that the waterworks men be leaders in their respective communities in building up the return of confidence which is essential in order for the country to pull out of the present depression.

Mr. J. T. Campbell read the paper on "Distribution Systems" by D. E. Davis, of the J. N. Chester Engineers, Pittsburgh, Pa. This paper was discussed by Messrs. E. E. Jacobson, John Chambers, J. T. Campbell, J. L. Thompson, J. T. Kingsley, G. B. Shawver, L. S. Vance, Dr. A. T. McCormack, E. J. Miller, and W. D. Weidlein.

The afternoon session convened at 2:15 P.M., with a paper on "Water Rates for Small Cities" by F. E. Beck, General Manager, Lexington Water Co., Lexington, Kentucky. This was discussed by R. M. Watt, J. T. Campbell, Wellington Donaldson, Boone Baldwin, John Chambers, W. H. Lovejoy and H. K. Bell.

Next was a paper on "Obsolescent Waterworks and Their Rehabilitation" by C. N. Harrub, Consulting Engineer, Nashville, Tennessee. Discussion of this paper was given by H. K. Bell, J. T. Campbell, F. H. Waring, Wellington Donaldson, W. H. Lovejoy, and W. D. Weidlein.

A paper on "Iron Removal" was given by Wellington Donaldson, Consulting Engineer, New York City, with discussion by J. T. Campbell, John Chambers and F. H. Waring.

A report of the work done by the U. S. Public Health Service on "Efficiency and Limitations of Water Purification Processes" was given by H. W. Streeter, Sanitary Engineer of the U. S. Public

Health Service. Discussion was taken part in by F. H. Waring and W. H. Lovejoy.

The evening session consisted of a dinner dance, at which Mr. Beekman C. Little, Secretary of the American Waterworks Association, brought greetings, and gave an account of what had taken place at the meeting of the Board of Directors in January.

Mr. James Tandy Ellis, formerly Vice President of the Owensboro Water Company, and former Adjutant General for the Commonwealth of Kentucky, gave an entertaining talk and showed his skill with the banjo.

The Friday morning session opened with a paper on "Coagulation" by Martin E. Flentje, of the Community Water Service Co., Harrisburg, Pa., which was followed by a paper on "New Method of Flocculation" by Frank Bachmann, Sanitary Engineer of the Dorr Company, Chicago, Ill. F. H. Waring, J. J. Quinn, H. W. Streeter, and Wellington Donaldson took part in the discussion of the two papers.

"Coagulation and Taste Control with Powdered Activated Carbon" was the subject of a paper by Mr. F. E. Stuart, of the Industrial Chemical Sales Corp., New York City.

In the afternoon session a discussion of the paper by Mr. Stuart was given by J. J. Quinn, M. E. Flentje, and W. H. Lovejoy.

Mr. J. T. Campbell read a paper entitled, "Factors Affecting Rate Making for Water Services" by Mr. E. E. Bankson, of the J. N. Chester Engineers, Pittsburgh, Pa. This paper was discussed by O. L. Holmes.

Mr. F. H. Waring, Chief Engineer of the Ohio State Health Department, spoke on "Checking of Small Plant Operation by State Department of Health in Ohio." This brought out discussion by A. E. Clark, F. C. Dugan and W. H. Lovejoy.

A round table discussion on "Extensions to Sub-divisions and Consumers Beyond City Limits" was taken part in by L. S. Vance, F. E. Beck, G. B. Shawver, O. L. Holmes and W. J. McGonigale.

"Charges for Fire Hydrants and Sprinkling Systems" by G. B. Shawver, B. E. Payne, C. N. Harrub, F. E. Beck and O. L. Holmes.

"Covered vs. Open Reservoirs" by F. H. Waring, H. D. Schmidt, F. C. Dugan, Wellington Donaldson, and J. J. Quinn.

The Nominating Committee reported, and the following were elected:

Chairman: G. B. Shawver, Superintendent of Operation, Tennessee Electric Power Co., Chattanooga, Tenn.

Vice Chairman: L. S. Vance, Assistant Engineer of the Louisville Water Company.

Trustees: W. G. Lanham, Resident Engineer, Board of Water Commissioners, Memphis, Tennessee, and J. T. Kingsley, Superintendent of Waterworks, Covington, Kentucky.

On invitation, Knoxville, Tennessee, was designated as the meeting city for 1934.

Saturday morning, Chairman H. K. Bell announced that the Executive Committee re-elected F. C. Dugan, Chief Engineer of the Kentucky State Board of Health, as Secretary and Treasurer for the coming year.

Mr. H. N. Jernigan read a paper by Mr. G. R. Kavanaugh of Wallace & Tiernan Company, on "Some Economic Aspects of Chlorination." This paper was discussed by A. E. Clark, Wellington Donaldson and P. J. Cerny.

Mr. H. D. Schmidt read a paper on "Improving the Status of Water and Sewerage Systems as Public Utilities" by Roy J. Morton, Chief Engineer of the Tennessee State Department of Health. This was discussed by Wellington Donaldson and C. N. Harrub.

Round table discussion on "Unaccounted-for Water" was taken part in by E. E. Jacobson and R. C. Wyatt; on "Free Water to Public Buildings and Institutions" by B. E. Payne and O. L. Holmes; on "Aeration" by E. L. Vogt, Wellington Donaldson, and G. B. Shawver; "How Are Complaints Handled in the Water Office" by L. S. Vance and R. C. Wyatt.

A paper entitled "Recent Pumping and Filtration Installations at the Nashville Plant" by R. L. Lawrence, Jr., Superintendent, was read by the Secretary.

The Resolutions Committee reported, and among the resolutions adopted, was one extending sympathy to the family of Mr. James Sheehan, who died shortly after the Memphis Convention of the American Waterworks Association; and, also, a resolution extending greetings and best wishes to Mr. W. S. Cramer of Lexington, Kentucky, who has been very ill.

After adjournment, the members were taken for an inspection trip to the Louisville Water Company, where lunch was served.

F. C. Dugan,
Secretary-Treasurer.

THE ILLINOIS SECTION

The meeting was called to order by Chairman Baylis at Rockford, Illinois on April 20, 1933.

A motion to approve the minutes of the Urbana Meeting of 1932, as sent out to the membership in mimeographed form, was carried.

The Resolutions Committee, composed of George B. Prindle, Chairman; W. W. DeBerard, and C. S. Gill, reported as follows:

Mr. Prindle reported a resolution, expressing the appreciation of the Section, to the City of Rockford, the management of the Nelson Hotel, and the Rockford Chamber of Commerce, for the courtesies shown in connection with the meeting.

Mr. Prindle also reported a resolution expressing the appreciation of the Section to the Mueller Company of Decatur for the presentation of a gavel to the Chairman.

Mr. DeBerard reported a resolution on the deaths of Mr. H. E. Keeler and of Mr. C. H. Koyl, and also a resolution of felicitation and support to Mayor Edward J. Kelly of Chicago.

Mr. Gill reported a resolution on the enactment of legislation for the issuance of certificates to waterworks superintendents, chemists, and operators, and also a resolution on the obtaining of money from the Reconstruction Finance Corporation for needed sewage disposal work.

All resolutions were adopted unanimously.

Copies of all resolutions are attached to these minutes and are a part thereof.

The Tellers Committee, composed of Charles H. Spaulding, Chairman; Frank R. Shaw, and Frank C. Amsbary, Jr., reported and the following officers were elected:

Chairman, J. J. Woltman, Bloomington; Vice Chairman, L. I. Birdsall, Glencoe; Treasurer, A. E. Skinner, Chicago; Trustee (term expiring 1936) H. E. Babbitt, Urbana; Section Director, W. R. Gelston, Quincy.

The Committee on Scope and Policy, through Mr. A. E. Gorman, Chairman, supplemented the report which had been read at the dinner on April 19. Mr. Gorman discussed the existing Constitution. Discussion followed which was participated in by Messrs. Burdick, Gorman, Spaulding, Baylis, B. K. Little, Secretary of the American Water Works Association, Prindle, Ferguson, Babbitt, and Enger.

Mr. Birdsall suggested a recess for lunch during which time representatives of the groups having diverse opinions might reach a compromise. The suggestion was adopted and a recess taken.

The meeting was called to order at 1:50 p.m. by Chairman Baylis. Mr. Gorman detailed the changes in the proposed Constitution which had been agreed upon by a majority of those participating in the luncheon discussion. The new Constitution was then adopted by a vote of 31 ayes. No negative votes were recorded.

A copy of the Constitution as adopted was not available to the Secretary. Mr. Gorman agreed to forward to the Secretary the necessary copies upon completion of stenographic work.

The meeting adjourned at 2:15 p.m.

WHEREAS, God in His mercy has called from his long life of usefulness our friend and counselor, Charles H. Koyl, member of the Illinois Section of the American Water Works Association,

Be It Resolved, Therefore, That we express our sincere sympathy to Mr. Koyl's family, and request that the Secretary be ordered to spread a suitable record upon the minutes of the Section and send a copy to Mr. Koyl's family. Further, that a suitable appreciation and biographical record of Mr. Koyl's long years of service be prepared by a committee to be appointed by the Chairman.

WHEREAS, God in His mercy has called from his long life of usefulness our friend, guide, inspiration, and counselor, H. E. Keeler, treasurer of this Section and honorary member of the American Water Works Association,

Be It Resolved, Therefore, That we express our sincere sympathy to Mr. Keeler's family, and request that the Secretary be ordered to spread a suitable record upon the minutes of the Section and send a copy to Mr. Keeler's family. Further, that a suitable appreciation and biographical record of Mr. Keeler's long years of service be prepared by a committee to be appointed by the Chairman.

WHEREAS, The City of Chicago has recently elected an outstanding engineer, Edward J. Kelly, having a long career of administering the sanitary engineering problems of the Sanitary District of Chicago, and

WHEREAS, This honor is unusual in that the profession has been thus honored but twice before in the history of the city, Messrs. Mason and Cregier having served as mayors in early days, and

WHEREAS, Other technical and engineering organizations are presenting similar appreciation testimonials to Mayor Kelly during Engineering Week at the World's Fair,

Be It Resolved, That the Illinois Section of the American Water Works Association extend to Mayor Kelly its whole-hearted support in carrying out his heavy responsibilities especially with reference to future water works problems, and further, That the Board of Directors of the parent association

be requested to join with this Section and other national and technical societies in presenting during Engineering Week at the World's Fair their felicitations and support to Mayor Kelly.

RESOLUTION OF THE ILLINOIS SECTION OF THE AMERICAN WATER WORKS ASSOCIATION, URGING THE ENACTMENT OF LEGISLATION WHICH WILL PERMIT ILLINOIS CITIES TO OBTAIN MONEY FROM THE RECONSTRUCTION FINANCE CORPORATION FOR THE CONSTRUCTION OF NEEDED SEWAGE DISPOSAL PLANTS

WHEREAS, The Federal Government has set up the Reconstruction Finance Corporation and a sum of One Billion Five Hundred Million Dollars to be loaned for various needed employment giving projects, and

WHEREAS, In order to secure loans from this fund, the project must be self-liquidating by means of service charges, rents or fees, to be paid over a period of a year by the persons benefiting from such construction, and

WHEREAS, Most States have provisions in their laws for financing sewage disposal works by tolls, service charges or rental and are, therefore, able to obtain loans. *Illinois laws at present do not permit its cities to obtain funds from the reconstruction finance corporation for sewage disposal construction*, and

WHEREAS, There were introduced in Illinois General Assembly on February 7th, 1933, Senate Bills No. 245 and No. 246 for the purpose of amending the present law under which sewerage projects are financed in Illinois in order to make such project eligible for loans under the said Reconstruction Finance Act,

Therefore, Be It Resolved, That the Illinois Section of the American Water Works Association will go on record as favoring the enactment of these two bills at the present session of the Legislature, and that a copy of this resolution be sent to the Honorable Governor, Henry Horner, at Springfield, Illinois.

RESOLUTION OF THE ILLINOIS SECTION OF THE AMERICAN WATER WORKS ASSOCIATION, URGING THE ENACTMENT OF LEGISLATION WHICH WILL PERMIT THE STATE TO ISSUE AND ENFORCE CERTIFICATES ISSUED TO SUPERINTENDENTS, CHEMISTS, AND OPERATORS OF WATER PLANTS

WHEREAS, The Southern and Central Plant Operators Association has sponsored a movement for the enactment of legislation which will empower the State to issue and enforce certificates to superintendents, chemists, and operators of water plants, and

WHEREAS, This is a much needed move for the protection of the health of the people of Illinois and the safeguarding of the water plant employees,

Therefore, Be It Resolved, That the Illinois Section of the American Water Works Association does hereby go on record as approving this movement, and further, extends its coöperation in any way possible to obtain this legislation.

J. J. DOLAND,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

General Instructions to Municipalities for Their Guidance in Purifying and Sterilizing Potable Waters (in France). Anon. Ministry of Labor, Hyg., and Social Life, Circ. (unnumbered) August 12, 1929; L'eau, 23: 23–8, 1930. From Chem. Abst., 24: 4878, October 10, 1930. General instructions covering physical and chemical properties of water, water sources, sedimentation, filtration, coagulation, and sterilization. Chlorination, or use of Javel water, is strongly recommended.—*R. E. Thompson.*

Sterilization of Potable Water by Means of Sodium Hypochlorite (Javel Water) Using the Automatic Sterilizer of the Soc. auxillaire des distributions d'eau (S. A. D. E.). Tech. sanit. munic., 25: 158–65, 1930. From Chem. Abst., 24: 4878, October 10, 1930. An automatic chlorinator is described which is simple, cheap, effective, and enduring.—*R. E. Thompson.*

Water Purification in Tropical Countries. Jules Casteels. Tech. sanit. munic., 25: 60–2, 1930. From Chem. Abst., 24: 4878, October 10, 1930. Discussion of use of alum, chlorine, softeners, etc.—*R. E. Thompson.*

A New Method for the Identification and Estimation of Nitrates in Water. G. Bini. Atti accad. Lincei, 11: 593–6, 1930. From Chem. Abst., 24: 4878, October 10, 1930. Hydroquinonesulfonic acid is suitable reagent for identification of nitrates in water, giving green to brown-green coloration with 0.001 percent nitric acid. Nitrites up to 0.02 percent do not interfere. Chromate and hydrogen peroxide give same reaction as nitric acid, but high chlorine-ion concentration prevents the reaction. It is less sensitive than pyrogallolsulfonic acid, which gives coloration even with distilled water. Reaction may be made quantitative by using 10 cc. water, 0.5 cc. reagent, and 20 cc. nitric acid-free sulfuric acid and comparing colors with aid of colorimeter.—*R. E. Thompson.*

---

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

The Determination of the Biochemical Oxygen Demand by Use of the Dilution Method in a Simple Form. H. J. MEYER. Gesundh.-Ing., **53**: 392-5, 1930. From Chem. Abst., **24**: 4879, October 10, 1930. The 2-day demand is used by author instead of the 5-day test, correction factors being applied to obtain 5-day values if desired.—*R. E. Thompson.*

Effect of the Alkalinity of Water in Brewing. G. VANDER STRICHT. Bull. assoc. élèves inst. sup. fermentations Gand, **31**: 238–44, 1930. From Chem. Abst., **24**: 4891, October 10, 1930. Carbonates and bicarbonates decreased the yield of extract, decreased the maltose and increased the dextrin contents, increased time required for saccharification, retarded filtration and gave opalescent worts, and reduced total nitrogen, soluble nitrogen, amino nitrogen, and phosphate.—*R. E. Thompson.*

The Neutralization of Water (for Brewing). P. PETIT. Brasserie & malterie, **20**: 81–5, 1930. From Chem. Abst., **24**: 4892, October 10, 1930. Brief discussion of advantages of proper neutralization of water containing magnesium bicarbonate.—*R. E. Thompson.*

The Determination of Phenols in Coking-Plant Waters. A. TRAVERS and AVENET. Compt. rend., **190**: 875–6, 1930. From Chem. Abst., **24**: 4919, October 10, 1930. The phenols in an acid solution were distilled by superheated steam (350°) and sulfur compounds in aliquot of distillate oxidized with hydrogen peroxide. Excess of latter was destroyed, solution neutralized, and traces of cobalt salt added. Sulfuric acid was then added in excess and solution titrated with bromide-bromate solution, drop by drop, until odor of bromine was detected. Small excess of potassium iodide was added and iodine titrated with thiosulfate.—*R. E. Thompson.*

Fabric Defects Caused by Water. HERBERT C. ROBERTS. Textile World, **77**: 1756–7, 1930. From Chem. Abst., **24**: 4938, October 10, 1930. Three cases are cited where faulty water led to defects in wet finishing and dyeing processes.—*R. E. Thompson.*

The Determination of Oxygen in Sea Water. MAURICE NICLOUX. Compt. rend., **191**: 259–61, 1930. From Chem. Abst., **24**: 4999, October 20, 1930. Method of WINKLER (Z. anal. Chem., **40**: 523, 1901) was modified for determination of traces of oxygen in from 5 to 40 cc. of sea water. An inverted Y tube was used; from 0.1 to 0.6 cc. alkaline potassium iodide solution (potassium hydroxide 1.8 grams, potassium iodide 5 grams, water to 100 cc.) was introduced by long funnel into one leg, and from 0.05 to 0.4 cc. 30 percent manganese sulfate into other leg, and stopper with capillary tube pushed into top until certain mark was reached. Reagents were then well mixed with sample by tipping tube back and forth, from 0.2 to 0.4 cc. phosphoric acid (60° Beaumé) added, and liberated iodine titrated with 0.01, or 0.005, normal sodium thiosulfate, 0.01 cc. corresponding to 0.0008 and 0.0004 milligram oxygen, respectively.—*R. E. Thompson.*

Experimental Study of the Methods for the Determination of Cresols. P. DUMONT. J. pharm. Belg., 12: 1, 21, 41, 65, 87, 1930. From Chem. Abst., 24: 5002, October 20, 1930. Bibliography is given of methods for determining cresols. Methods involving use of bromine and iodine are not suitable for analysis of mixture of 3 cresols in solution. By means of bromine, however, each of the 3 cresols can be determined separately. Factors influencing fixation of bromine are listed and discussed. It is possible to determine *m*-cresol in mixture of the 3 cresols by titration with bromine. In any mixture of cresols, *o*-cresol can be estimated colorimetrically by using bromine. Chemical methods, other than those dealing with bromine and iodine, used for determination of phenols are not suitable for extraction of cresols. Among physical methods, steam distillation procedure and process involving extraction by means of suitable solvent, with subsequent evaporation of latter, are only methods that give good result. RASCHIG's method modified by QUIST is suitable for estimation of *m*-cresol in mixtures.—*R. E. Thompson.*

Carbonates in the Sediments of Lake Geneva. JEAN ROMIEUX. Arch. sci. phys. nat. (5), 12: 202–16, 1930. From Chem. Abst., 24: 5005, October 20, 1930. Sediments of the lake are divided into 3 principal regions: eastern, central, and western. The sands, muds, etc., are described and carbon dioxide content at many points is given.—*R. E. Thompson.*

Corrosion of Copper. II. Electrochemical Behaviour and Protective Film Formation. L. W. HAASE. Metallwirtschaft, 9: 532–4, 1930; cf. C.A., 24: 3977. From Chem. Abst., 24: 5011, October 20, 1930. Review of facts concerning corrosion of copper and copper alloys, emphasizing tendency toward acceleration of solution of metal in presence of oxygen, at welded spots, of solder from soldered joints unless solder contains much silver, and of tin from tin-plated copper when covering is incomplete. With copper alloys the more basic metal tends to dissolve out first. Use of built-up protective films such as of calcium carbonate, is mentioned. Chlorides and humic substances retard formation of heterogeneous protective films. Homogeneous protective films afford better protection and are built up by reaction of metal with oxygen, hydrogen sulfide, or carbon dioxide in water. Former are usually formed in waters with high dissolved solids content, whereas latter may be formed in any type of water. III. Ibid., 559–60. Review of facts on corrosion of copper in potable waters, emphasizing relative inertness of copper toward oxygen-free water. Carbon dioxide in absence of oxygen does not cause any appreciable deterioration of the metal. Copper pipes in soils containing oxides of iron are apt to be cathodic and receive deposits of anions of compounds found in soil water on the surface, with subsequent formation of incrustations which are protective. Small amounts of copper in water are not injurious to human organism. Copper pipe may be used safely for practically all lines conducting potable waters.—*R. E. Thompson.*

Apparatus for Testing the Water Permeability of Concrete. ROBERT OTZEN. Zement, 19: 274–7, 1930. From Chem. Abst., 24: 5127, October 20, 1930. Several types are described, accommodating disks and other shapes of test specimens.—*R. E. Thompson.*

A Proposed Method for Accurately Evaluating Results of Corrosion Tests of Ferrous Metals. KARL PITSCHNER. Trans. Am. Electrochem. Soc., 58 (preprint): 12 pp., 1930. From Chem. Abst., 24: 5010, October 20, 1930. Methods of procedure, analysis, and calculation are described which provide definite means of evaluating data of corrosion tests on ferrous metals, of determining actual protective value of coatings on these material, and of comparing their tendencies to pit under corrosive conditions. Procedure depends on methods for determining the element iron in metallic portion of corroded samples by separation of corrosion product from metal with crystalline iodine.—*R. E. Thompson.*

Speed of Germicidal Action of Chlorine Compounds on Bacteria Commonly Occurring in Milk. C. K. JOHNS. Sci. Agr., 10: 553–63, 1930; cf. C.A., 24: 4097. From Chem. Abst., 24: 5077, October 20, 1930. Relative bactericidal efficiencies of various chlorine preparations were studied using *B. coli*, *Aërobacter aërogenes*, *S. lactis*, and *B. subtilis* as test organisms. Chloramine-T preparations were uniformly slow in action, while liquid hypochlorite preparations were rapid and effective against all but spore formers. Spores of *B. subtilis* were not destroyed by any of the chlorine disinfectants. Losses of available chlorine were least with chloramine-T preparations.—*R. E. Thompson.*

Determining Air Flow in Agitation Problems. H. L. KAUFFMAN. Chem. Met. Eng., 37: 178–80, 1930. From Chem. Abst., 24: 5085, October 20, 1930. Violence of agitation produced under varying conditions by different quantities of air is indicated. Pressure required to produce agitation is the sum of 3 factors: (1) head of liquid, (2) friction in pipe, (3) pressure difference required to force air through orifices or openings. Determination of degree of agitation required should take into consideration 3 related facts: (1) degree of agitation depends upon quantity of air flowing and upon velocity with which air leaves openings; (2) agitation increases more rapidly than rate of flow of air; (3) better agitation is obtained with deep tanks than with shallow ones, air volume being constant.—*R. E. Thompson.*

Notes on the Analysis of Alkali Hypochlorites. F. HERNANDEZ. Quim. e ind., 7: 177–8, 1930. From Chem. Abst., 24: 5001, October 20, 1930. Iodine, or sodium arsenite ($NaAsO_2$), method is used to determine active chlorine. Silver nitrate method is preferably used to determine total chlorine. Chlorates are determined by decomposition with hydrochloric acid, distilling into 5 percent potassium iodide, and titrating with 0.1 normal thiosulfate. Hypochlorites must be destroyed prior to determining alkalinity. This may be effected with neutral oxidants, care being taken not to add or develop acid, but preferably by evaporation to dryness. Residue is dissolved, absence of hypochlorite verified, and alkalinity determined by titration with 0.1 normal hydrochloric acid using phenolphthalein as indicator.—*R. E. Thompson.*

Pneumatic Transport of Granular and Powdered Materials. H. NEU. Bull. soc. ing. civils France, 82: 987–1041, 1930. From Chem. Abst., 24: 5086,

October 20, 1930. Pneumatic method of transporting materials requires pressure difference of from 100 to 450 millimeters of mercury and air supply of from 30 to 500 liters per kilogram of material, according to circumstances. Calculation of an installation, which cannot be performed by theory alone, permits of two solutions: minimum capacity and most economical capacity. Various methods of feed and discharge are described together with types of pumps for production of pressure, or vacuum. Pneumatic transporters can deliver up to 300 tons per hour; they are flexible and economical in labor, but have higher power consumption than other types. Little room is required and the crossing of obstacles such as railway lines presents no difficulty.—*R. E. Thompson.*

Centralized Control of Water Supply Systems in Large and Medium Sized Cities. A. Denkert. Gas- u. Wasserfach, **73**: 702–7, 724–30, 1930. From Chem. Abst., **24**: 5087, October 20, 1930. Distant recorders of volume and of rate of flow as well as of height of water in tanks, reservoirs, etc., are discussed, together with distant operation of valves and indicators of valve position.—*R. E. Thompson.*

Variations of Hydrogen-Ion Concentration in the Neighborhood of the Estuary of the River Murray. T. Brailsford Robertson. Trans. Proc. Roy. Soc. S. Australia, **53**: 39–44, 1929. From Chem. Abst., **24**: 5088, October 20, 1930. Samples of water were taken at uniform depth of 4 feet. H-ion concentration was studied because it has been found important in connection with life of organisms. Tables of results are given. Murray River Water is about 10 times as alkaline as sea water, pH value of former being 8.9 and of latter 8.0. Water in the Cooroung resembles river water. Its high alkalinity may be due to evaporation of river water, or to great abundance of algae. Formation of sand bars may be due partly to deposition of calcium and aluminum phosphates as result of this high alkalinity.—*R. E. Thompson.*

Purification of Water for the Textile Industry. M. Varinois. Tiba, **8**: 591–7, 711–7, 1930. From Chem. Abst., **24**: 5089, October 20, 1930. Brief description of methods of treatment available for purification of water to suit requirements of textile industry, with particular reference to softening by zeolite process.—*R. E. Thompson.*

Chemical Precipitation of Humus Coloring Matters. C. P. Mom and O. H. van der Hout. Mededeel. Dienst Volksgezondheid Nederland.-Indië, **19**: Pt. 1, 23–9, 1930. From Chem. Abst., **24**: 5090, October 20, 1930. Description of attempts to make potable the waters of a swamp near Pontianak, Borneo. Chemicals ordinarily used for sedimentation and chlorination were not satisfactory.—*R. E. Thompson.*

Powdered Fuels in Modern Boilers. V. Sázavský. Chem. Listy, **24**: 101–4, 1930. From Chem. Abst. 24, 5131, October 20, 1930. Use of powdered fuels permits design of highly efficient and high pressure boilers. For efficient functioning, water must undergo rigorous chemical control, which author discusses in detail.—*R. E. Thompson.*

Considerations on the Water Used for Producing Beer. GIOVANNI CAPRINO. Zymologica, zym., chim. col. e zucch., 5: 47–55, 1930. From Chem. Abst., 24: 5106, October 20, 1930. Discussion of effects of mineral constituents and methods of correcting waters for use in brewing.—*R. E. Thompson.*

Lime Exudations on Concrete Under Water. G. HAEGERMANN. Bautenschutz, 1: 1, 13–5, 1930; Building Sci. Abstracts (N.S.), 3: 124–5. From Chem. Abst., 24: 5127, October 20, 1930. Brown crystalline incrustation 1 to 2 millimeters thick, with occasional porous protuberances of size of a hazel nut, were found on concrete immersed in river water. Incrustation was found to consist of calcium carbonate together with small amounts of silica, magnesia, and iron oxide. Specimens of cement, both poor and rich in lime, immersed in the water after 7 days' curing in air, displayed the same phenomena in few days. River water had following composition: sulfate (SO_3), 11.5; combined carbon dioxide, 102.2; free carbon dioxide, 4.4; lime (CaO), 105.0; magnesia (MgO), 14.1; iron and alumina oxides, 17.0 p.p.m. Analysis of the water after a 2-day old specimens of 1:3 cement mortar had been stored in it for 2 days showed that lime 5.20, magnesia 6.95, and iron and alumina oxides 17.0 p.p.m. had been removed from solution. About one-half the incrustation thus originates in the water. Formation of this crust is attributed to reaction between calcium bicarbonate in solution in the water and calcium hydroxide solution formed in pores of concrete. Protuberances were found to coincide with openings of large pores. Apart from unsightly appearance, crust is not thought to have any harmful effect, as pores of concrete are soon sealed with calcium carbonate and reaction comes to an end. Affected concrete was 1:7 rammed mix and was more porous than usual.—*R. E. Thompson.*

The Effect of Altitude on Power Equipment. F. H. DUTCHER. Power, 71: 949–51, 1930. From Chem. Abst., 24: 5132, October 20, 1930. Non-condensing steam engine with initial pressure of 150 pounds will have 11 percent greater working capacity at 10,000 feet than at sea level. Available power of internal combustion engines is proportional to air density. Supercharger should be used for latter and blower, or high-pressure fan, for electric motors.—*R. E. Thompson.*

Refuse from the Coal-Tar Plants. S. M. KROLEVETZ. Zhur. Prikladnoi Khim., 3: 413–35, 1930. From Chem. Abst., 24: 5136, October 20, 1930. Refuse from coal tar plants is very harmful to animal and fish life, and therefore should not be discharged into rivers. Disposal methods are discussed.—*R. E. Thompson.*

Application of Sodium Aluminate in Water Supply Systems of Pulp and Paper Mills. G. J. FINK. Cellulose, 1: 38–42, 1930. From Chem. Abst., 24: 5154, October 20, 1930. Factors of volume and distribution of water, its color and hardness, and treatment methods are discussed. Bibliography of 13 references is appended.—*R. E. Thompson.*

Manufacture of Copper Tubing and Application to Water-Conducting Pipe. ALFRED SCHIMMEL. Apparatebau, 42: 109–12, 1930. From Chem. Abst., 24: 5184, November 10, 1930.—*R. E. Thompson.*

Solubility Relations in Gas-Liquid Systems. II. The Solubility and Rate of Solution of Oxygen in Water. J. LIVINGSTON, R. MORGAN, and H. RIVINGTON PYNE. J. Phys. Chem., **34**: 1818–21, 1930; cf. C.A., 24, 4688. From Chem. Abst., **24**: 5203, November 10, 1930. Solubility and rate of solution of oxygen in water at 25° were determined with new type of solubility apparatus recently described. Results agree with values obtained by other methods.—*R. E. Thompson.*

Iodine Investigations in Bad Hall in Upper Austria. TH. VON FELLENBERG. Mitt. Lebensm. Hyg., **21**: 188–204, 1930; Biochem. Z., **224**: 176–92. From Chem. Abst., **24**: 5262, November 10, 1930. Study of different iodine springs from drill holes at Bad Hall showed values of from 11.1 to 47.5 p.p.m. These springs are among the richest of middle Europe. The iodine is present as iodide. The soil is poor in iodine and stratum from which the iodine-rich water arises is also poor in iodine and in organic matter. Drinking and river water are rich in iodine. About 0.48 milligram iodine is absorbed through the skin during bathing period of one-half hour in iodine-rich waters.—*R. E. Thompson.*

Rôle of Hydrogen-Ion Concentration in the Precipitation of Calcium and Magnesium Carbonates. H. P. CADY, G. KEMMERER, and MARY E. WEEKS. J. Phys. Chem., **33**: 1769–80, 1929. From Chem. Abst., **24**: 5205, November 10, 1930. The pH values of calcium bicarbonate at 25° and 33° and of solutions of magnesium bicarbonate at 33° were determined by potentiometric method. The pH at which precipitation of carbonate takes place is linear function of concentration of oxide concerned. Rise in temperature of 8° raises the pH precipitation value for calcium bicarbonate by 0.045 unit. Magnesium bicarbonate solutions lose carbon dioxide before precipitation value of pH is reached, but this is not the case with the calcium salt. Empirical equations giving pH value at which precipitation of the carbonate will occur are recorded.—*R. E. Thompson.*

Determination of Active Chlorine in Hypochlorite Liquors. J. D. BLAKELEY, J. M. PRESTON and F. SCHOLEFIELD. J. Soc. Dyers Colourists, **46**: 230–4, 1930. From Chem. Abst., **24**: 5253, November 10, 1930. Electrometric determination of active chlorine in hypochlorite solutions by PENOT and bromate methods is described. Figures and curves for sample titrations, together with descriptions and diagrams of necessary equipment, are included. Method is recommended for routine analysis.—*R. E. Thompson.*

Cesium Sulfate as a Confirmatory Reagent in the Detection of Aluminum. HERMAN YAGODA and H. M. PARTRIDGE. J. Am. Chem. Soc., **52**: 3579–80, 1930. From Chem. Abst., **24**: 5253, November 10, 1930. Formation of $Cs_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\ H_2O$ crystals containing only 4.75 percent aluminum can be used as simple and decisive test for aluminum. Dissolve the supposed aluminum hydroxide in from 1 to 5 cc. hot 6 normal sulfuric acid, cool, and add from 0.5 to 1.0 cc. 0.25 molar cesium sulfate solution. Less than 1 milligram of aluminum can be detected in 3 minutes. Bismuth is the only element likely to interfere seriously with test.—*R. E. Thompson.*

The Reading of Chemical and Bacteriological Reports. Anon. British Waterworks Official Circular, 14: 98, 38, February 1932. In order to straighten out diversities in analytical reports, it is suggested that chemical results should be given as averages and should include ammoniacal nitrogen, albuminoid nitrogen, nitrates, chlorides (as chlorine) oxygen absorbed from permanganate (3 hours at 80°F.), and total and permanent hardness. Some reference should be made to action on lead, with soft waters. Bacteriological results should give average numbers per cc. (agar at 37°C.) and, for treated water, percentage number of samples containing no *B. coli* in 100 cc.; for raw, or partially treated, water, *B. coli* results should be expressed per 10, or 1 cc., or even per 0.1, or 0.01, or smaller fraction, of 1 cc.—*W. G. Carey.*

The Chemistry of Boiler Water. H. E. Jones. Chemistry and Industry, 51: 4, 76–77, January 22, 1932 and 5, 98–99 January 29, 1932. Progress made in recent years in study of boiler water, difficulties due to varying nature of supply, and effects of adoption of water tube boilers and high pressures were discussed. Work done in America, England, and Germany was mentioned. In discussion, treatment with sodium phosphate and caustic soda for plant working at 400 pounds pressure was described; scale was prevented, but deposit of calcium phosphate and sodium chloride appeared on turbine blades. Sodium aluminate was recommended as remedy. Reference was made to prevention of caustic embrittlement by treatment of lime-soda softened water in permutit plant followed by neutralization with sulphuric acid. Formation of silicate scale after lime-soda and permutit softening was mentioned. It was stated that with every zeolite tested there was more silicate in treated than in untreated water, and that water might indicate zero hardness and yet contain traces of calcium and magnesium.—*W. G. Carey.*

Copper Water Service Pipes. Anon. Water and Water Engineering, 34: 406, 353, July 20, 1932. Copper for service pipes is of increasing importance and is advantageous. British Non-Ferrous Metals Research Association has investigated action of different waters on various grades of copper, consequent upon green staining which occurs in some new installations. This trouble is found to be frequent with certain kinds of water and work has been extended to study wide range of artificially formed protective coatings on copper.—*W. G. Carey.*

Goyt Valley Water Supply, Stockport, England. Anon. Water and Water Engineering, 34: 405, 295–297, June 20, 1932. Scheme comprises two impounding reservoirs with capacity of 1400 million gallons, catchwaters, filters, trunk mains, and service reservoirs and is to be developed by stages as required. One reservoir, now under construction, is in strata consisting of massive beds of sandstone and shale alternating with each other. Embankment will be 120 feet high and 650 feet long and will consist of earthwork on each side of puddle core founded on concrete with which central trench will be filled. Water will be withdrawn through discharge tunnel 650 feet long, and valve shaft 12 feet in diameter will permit water withdrawal at different levels.—*W. G. Carey.*

The Water Supply of Bournemouth, England. P. G. G. MOON. Water and Water Engineering, 34: 406, 346–353, July 20, 1932; prepared for British Waterworks Association, June 1932. Supply is partly direct from river, partly from gravel beds beside river, and partly from deep well in chalk, yield from which is diminishing. Well water is softened in Haines softener and filtered through twill cotton cloth. Trouble with gelatinous organisms in cloth was overcome by chlorination, at rate of 0.3 p.p.m. River water is raised by Worthington direct-acting steam pumps, Pulsometer steam-driven centrifugal pump, and Allen turbo-centrifugal pump. Steam is supplied from water-tube boilers fired by coke breeze. Water turbine pumps are also available whenever stream flow is sufficient, thus saving $5000 per annum. Water is treated with alum and ammonium sulphate in central sump, pumped to sedimentation tank, and thence to pressure filters. These are washed by air and water, wash water being settled and returned to river. Water is chlorinated with from 0.75 to 2.0 p.p.m. in contact chamber giving from 2.3 to 7 hours contact and then dechlorinated with sulfur dioxide. Activated carbon chambers are provided so that dechlorinated water can pass through 2-foot layer, should any taste develop during flood conditions. Reservoir of 12-million-gallon capacity is provided, over which slow sand filters are constructed. Owing to height above ground, combined travelling elevator and sand washer runs on rail on reservoir wall. Water from river and from culverts in gravel beds beside river is passed, if necessary, through these gravity filters, but ordinarily pressure filters suffice.—*W. G. Carey.*

Contamination of Water by Lead and Copper. Engineering, 133: 3456, 435, April 8, 1932. Well water conveyed to house by cast iron pipes was distributed in lead pipes for cold supply and in copper pipes for hot supply. Color led to examination, showing pH 6 and free carbon dioxide, 36 p.p.m. Lead in cold supply was 1.2 p.p.m. and copper in hot supply was 1.8 p.p.m. Dangerous lead content was thus only revealed because of color due to copper. Magnesite filter was fitted at concrete supply tank.—*W. G. Carey.*

A New Method for the Isolation of B. Coli in Water. G. FLEURY. Chemisches Zentralblatt, 1: 1280, 1932. One cc. of water under examination is added to 15 cc. of nutrient medium (liquid at 42°C., solid at 35°C.) colored with Congo red. After from 1 to 3 days incubation at between 25 and 30°C., colonies of *B. coli* appear blue and those of *B. typhosus*, dark red. Bacteria commonly occurring in water can also be determined by this process. [Congo-red-agar has been in successful use by Dr. HARALD HUSS at Stockholm, Sweden, for many years: nor was he the first; e.g. ACIL and LIEBERMANN.—ABSTR.]—*W. G. Carey.*

Barium Aluminate as a Water Softener. Chem. Trad. J., 1930, 86: 78. Commercial future of barium aluminate in field of water-treatment technology is mentioned. Preparation of barium aluminate of definite chemical composition is difficult. It is made on large scale by roasting mixture of natural barytes, bauxite, and coke on hearth furnace. Brownish powder soluble in water to extent of about one-half its weight is obtained. For use in water

softening, crude commercial product should be extracted with hot water to produce 10 percent solution. Reference is made to the work of R. STUMPER.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Compound for Use as Water Softener. BRUTON, G. R. B.P. 325,099; Chem. Indust., 1930, 49: B., 307. Mixture of equal parts of soda ash, "Crex" (sodium carbonate and bicarbonate), and powdered borax is claimed as compound for use as water softener.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Water Softening: Certain Properties of Some Base Exchange Materials. MARTIN, A. R. Chem. and Indust., 1930, 49: 197; read at meeting of Society of Chemical Industry, London Section. Researches are being carried out for Water Pollution Research Board on properties of various natural and synthetic base exchange materials used in water softening. Results are recorded in tables giving (1) exchange values at varying rates of water flow, (2) bulk densities, and (3) volumes of interstitial spaces. Base exchange values are higher for synthetic, than for natural materials, as in latter, which are nonporous, exposed surface is much less than in former, which are porous. Some figures regarding single and double regeneration were quoted. In discussion, COSTE, J. H., referred to skilled attention needed by water softening plants and to possibilities of supplementing lime-soda softening by base exchange processes. PARKER, A., referred to softening of salt water and of hot water by base exchange processes and to mechanism of reactions. COX, H. E., mentioned that, unless great care was exercised with base exchange plants, there was the possibility of getting at various times soft water, hard water, and salt water.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Process and Apparatus for Continuous Water Softening. NORDELL, C. H.; Assr. to Permutit Co. U. S. P. 1,740,199; Chem. Zbl., 1930: 1, 1668. Detailed description given. Water is led against stream of fine zeolite in elongated vertical chamber. Zeolite collects at bottom, passes into regenerating vessel, and then back into circulation. Diagram of apparatus is included.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Process and Apparatus for the Automatic Regeneration of Base Exchange Substances for the Softening of Water. Établissements Phillips Et Pain. F.P. 652,665; Chim. et Indust., 1929: 22, 1109. Arrangement operated by action of softened water is connected with softening apparatus and automatically controls normal course of operation, regeneration, and washing. Control is by branch from the softened water main, discharge through which bears constant proportion to flow in main. Salt solution is automatically prepared while apparatus is in operation.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Apparatus for Regeneration of Filtering Material Used in Water Softening Filters. RUHLANDWERK A.-G. G.P. 458,017; Chem. and Indust., 1930, 49: B., 266. Filter is connected with vessel, preferably funnel-shaped, containing regenerating fluid, by tube fitted with three-way tap. On completion of regenerating process and flushing with water, tap is turned to deliver water to be softened into filter.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Sterilising Liquids. KRAUSE, G.A. B.P. 325,796; Ill. Off. J. Patents, 1930: No. 2153, 1006. Descriptions, with diagrams, are given of various types of apparatus for partial, or complete, sterilization of liquids by contact with oligodynamically active substances.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Sterilising Liquids. KRAUSE, G. A. B.P. 325,004; Ill. Off. J. Patents, 1930: No. 2150, 702. Water and other liquids are sterilised and preserved by bringing them into contact with metals exerting oligodynamic action, or with salts, or other compounds or alloys, thereof, liquids being filtered before, or after, treatment. Five different forms of apparatus for sterilization and filtration are described and illustrated. In other methods described, vessel, or its inlet or outlet conduits, may be coated, or impregnated, with the metal; or the metal may be arranged between two filters.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Ozone and Its Applications. OTTO, P. Bull. Soc. Franç. Electr., 1929: 9, 129; Chim. et Indust., 1930: 23, 383. Industrial production and application of ozone are discussed, with particular reference to sterilization of drinking water. Several installations are described and advantages of ozone over chlorine are given. Article contains numerous illustrations.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

An Improved De-aërator for Boiler Feed Water. Engineer, 1930, 149: 332. Description and diagrams are given of new type of de-aërator with self-contained heater for treating feed water to boilers and economisers. De-aërating process is carried out in two stages. Feed water is delivered under pressure and passes as cooling agent through centrally placed condenser tubes, condensing steam from final de-aëration, and so is raised in temperature. It then passes into upper chamber through float-operated spray valve and is further heated by low-pressure steam. Partial de-aëration is effected in spraying, air and gas liberated escaping through air-vent. Sprayed water and condensed steam collect at bottom of upper chamber and pass through lower spray valve into lower, or main, de-aërating chamber, where vacuum is maintained by combined action of above-mentioned surface condenser and steam-operated air ejector. Temperature in lower chamber is not less than 25°F. higher than that

of entering feed water, so that in course of spraying, explosive boiling takes place which flashes part of water into steam and de-aërates all of it. Curves showing oxygen-content and temperature of water leaving de-aërator are included.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Water-Recovery Systems at the Fuel-Oil Testing Plant of the U. S. Navy Department at Philadelphia, Pa. BROSHEK, J. J. Am. Soc. Nav. Eng., **41:** 431; Eng. Abst., **1930:** New Series, No. 42, 112. Boilers at Fuel-Oil Testing Plant depend upon Philadelphia city, water, rich in incrustants. Resulting scale deposit causes overheating, is difficult to remove, and cannot be prevented by chemical treatment. Frequent cleaning of boilers is therefore necessary, tubes often burn out, and foaming and priming occur after short period. Condensers which recover water with but little loss have been applied and effort is made to use steam to fullest extent possible without loss of condensate. Details of operation are given.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Hetch Hetchy Project. M. M. O'SHAUGHNESSY. Water Works Eng., **85:** 9, 584, May 4, 1932. Waters from melting snows and glaciers of Sierra Nevada are impounded by great Hetch Hetchy System of San Francisco in two reservoirs, Hetch Hetchy and Lake Eleanor. From reservoirs, a gravity aqueduct, mainly tunnel, will conduct water to large local reservoirs at and near San Francisco. Completion of aqueduct will require less than two years, about 5 miles of tunnel remaining to be excavated. This 5-mile gap is being bridged by temporary pipe line, to carry portion of the water, which is scheduled to be complete and ready for operation in about three months. Day labor is used on tunnel. About $5 per foot for excavation and $11 per foot for lining is being saved as against contractors' prices. Tunnel now under construction is 28½ miles long, 23 miles of which is excavated and 11 miles lined. Ends of completed Red Mountain Bar Siphon, which is about 2515 feet long, are being connected to respective sections of Foothill Tunnel. Pipe is 9½ feet in diameter and has 1½- to 2-foot concrete coating and 1½-inch concrete lining. Sand trap is placed on upper end. Provision is being made for connection for penstock of 25,000-horse-power generating plant. The 47½ miles of 5-foot pipe across San Joaquin Valley is nearly complete. Where pipe runs through corrosive soil, ½-inch wrapped concrete coating is applied in addition to usual asphaltic coating. Where pipe is laid at great depth, 6-inch concrete coating and 1½-inch concrete lining are used. Corral Hollow Emergency Pipe Line is the 24-mile line of 36- and 44-inch pipe bridging the 5-mile gap in tunnel on which work is now in progress. Water will be pumped against total head of 655 feet. Four bond issues totalling $79,600,000 have been created and further issue of $6,500,000 will be necessary to complete the work.—*Lewis V. Carpenter*.

Ground Water Supply. HOWARD E. SIMPSON. Water Works Eng., **85:** 11, 686, June 1, 1932. Excessive pollution, hardness, and inadequacy of supply from Souris River forced Minot, N. D., to seek new supply. Artesian waters

were rejected, because of high mineral content and excessive pumping lift. Springs were bacteriologically pure, but inadequate. Wells into bed rock (sandstone) were also inadequate. Underflow of valley floor was proven adequate by test holes. Three wells were drilled and three-million-gallon concrete reservoir constructed. First well was 10 inches in diameter and 132 feet deep. Water stands within 10 feet of surface when not pumping and showed maximum drawdown of 25 feet after 12 hours continuous pumping at rate of 1500 gallons per minute. Second well is similar, but 12 inches in diameter. Third is a gravel wall well, 158 feet deep, with casings 20 and 12 inches in diameter. Seven-inch centrifugal pump is used at first well and 12-inch vertical turbine pumps at other two. Hardness, at first only 3 p.p.m., has increased materially with pumping: slight color and odor have also developed. Water from all wells is bacteriologically pure. Superstructures were designed as park houses with pumping station in center.—*Lewis V. Carpenter.*

A Difficult Pipe Repair. WILLIAM W. BRUSH. Water Works Eng., 85: 10, 634, May 18, 1932. In completing Catskill delivery tunnel, construction shafts were utilized for connections between tunnel and distribution system by inserting steel riser pipes and filling in solidly around them with concrete down to level of riser valve, 100 feet below surface of rock. This valve is operated either hydraulically, through 1½-inch brass pressure pipe, or manually, by rod through another 1½-inch brass pipe. Both these pipes are likewise incased in the concrete for their entire length. Leak developed in pressure pipe at 25 feet below surface of rock and was repaired, without having to remove 25 feet of concrete, by inserting a length of copper tubing and expanding it both above and below the break. Five expansions were made, giving three contacts above the break and two below. Special Dudgeon expander was used. No leaking has occurred since.—*Lewis V. Carpenter.*

Diesels for Water Service. ROBERT E. McDONNELL. Water Works Eng., 85: 10, 636, May 18, 1932. Small city pumping ½ m.g.d. against 200-foot head saved $3000 per year by installing Diesel rather than steam, or motor, drive. Main advantage of Diesel unit is low fuel cost. In tabulated comparison of B.T.U. consumed per k.w.h. generated two steam engines, two steam turbines, and one Diesel engine are compared. Diesel engine is the most efficient. Water works operated in conjunction with electric light plants often offer ideal conditions for Diesel installations. Demands upon skill of Diesel plant operator tend to withdraw it from sphere of politics. Central Diesel generating station can be used to furnish current for motor-driven pumps operating against either high or low pressure. Diesel engine may drive centrifugal triplex or duplex pumps, pumping direct from source to pressure mains; or it may drive high service pump direct, with direct-connected generator furnishing current for motor-driven low service pumps. Low operating cost of Diesel is due to high thermal efficiency. Thermal efficiency of highest type steam plant is only 28 percent, while that of Diesel engines averages 32 percent. Diesel engine installations are increasing rapidly.—*Lewis V. Carpenter.*

Sheboygan Purification Plant. JEROME C. ZUFELT. Water Works Eng., 85: 8, 424, April 20, 1932. New plant, filtering water from Lake Michigan,

recently placed in operation, cost $430,000, of which $330,000 was paid for out of earnings. It is typical rapid sand plant, with provision for aëration if needed.—*Lewis V. Carpenter.*

Control of Purification Processes. CHARLES R. COX. Water Works Eng., 85: 8, 427, April 20, 1932. While aëration will remove carbon dioxide, it will not promote, as does lime, protective film formation. Table exhibits pH values at which (1) corrosion is arrested, (2) calcium carbonate equilibrium is attained, and (3) excess calcium carbonate is deposited, for alkalinities from 25 to 200 p.p.m. Soda ash can be used to raise pH value and will precipitate calcium carbonate from water of greater hardness than 50 p.p.m. Lime must be used for soft waters. In marble test, the alteration which occurs in pH value [or in alkalinity] after at least 24 hours contact of the water with excess of pure calcium carbonate is determined. Methods for determining pH values and residual chlorine values are described. Nitrates, iron, and manganese are listed as interfering with *o*-tolidine reaction. When ammonia is present as well as chlorine, 30-minute reaction period is necessary for *o*-tolidine test.—*Lewis V. Carpenter.*

Graphical Representation of Mineral Components in Water Analysis. A. ADLER HIRSCH. Ind. Eng. Chem., Analyt. Ed., 4: 405, 1932. A rectangular form of graph is given.—*Edw. S. Hopkins.*

Discolored Water. Australian Municipal Journal, 12: No. 252, September 15, 1932. Measures adopted by Metropolitan Water Board of Sydney, Australia, to prevent discoloration caused by corrosion of mains are described. All new mains are lined with bituminous material: existing 2800 miles of 4- and 6-inch mains are being coated in place. Special plant has been devised to spray the lining material on to short sections of interior surface; so that treatment only involves shutting off short sections for brief intervals.—*E. B. Besselievre.*

Aëration. I. JOHN R. BAYLIS. Water Works and Sewerage, 79: 195–98, 1932. Theoretical discussion of effects of films at water-gas interface in aëration is adequately presented.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Aëration. II. Compounds Which May Be Removed from Water by Aëration. JOHN R. BAYLIS. Water Works and Sewerage, 79: 252–4, 1932.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Ottawa's New Filtration Plant. W. E. MACDONALD. Water Works & Sewerage, 79: 227–231, 1932. Detailed description of new 35-million-gallon rapid sand water purification plant is given.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Solving Subterranean Water Problems from Experience. F. SCHAFFERNAK and R. DACHLER. Die Wasserwirtschaft, 24: 1–4 and 36–40, January 5, 1931. Solution of problem dealing with flow of underground water will depend upon

(1) permeability of strata concerned and (2) velocity of flow through them. While experience is the only practical guide in estimating permeability, velocity of flow can be calculated mathematically with fair accuracy by integration of a differential equation, due to LAPLACE, which, however, is always difficult and sometimes impossible. Authors describe method of "model trial," which simplifies the calculations and which they claim can be made as accurate as the case in hand warrants.—*R. DeL. French.*

Flowing Boreholes in the Rehoboth, Cibeon and Gohabis Districts, South-West Africa. H. F. FROMMERZE. Trans. Geol. Soc. So. Africa, 35: 129–149, December 14, 1931. Description of interesting series of flowing wells, with cross-sections of strata penetrated.—*R. DeL. French.*

Progress and Problems of Electrical Prospecting. PAREFNOV, MILIKIAN, and NITIKIN. (In Russian.) Azerbaidjanskoe Neftianoe Khoziaystvo, 22: 7–14, 1932. Account of electrical exploration for oil by SCHLUMBERGER method in the Azneft Region, U.S.S.R. Authors conclude that this method is of great importance and usefulness as means of exploring the subsoil, and that it should be more widely used.—*R. DeL. French.*

Influence of the Geological Nature of the Soil and the Mineralization of the Water Supply on the Frequency of Human Cancer. F. BLANCHET and L. BETHOUX. Comptes Rendues de L'Acad. Sci., No. 19, 607, October 8, 1932. In Department of Isère, France, mortality rate from cancer is higher in north-west, where country rock is calcareous, than in south-east, where rocks are crystalline. Incidence is also greater in Basin of Paris than in Central Massif. Waters of crystalline regions generally are pure and sparingly mineralized. Authors conclude that study of geology should be tied in with that of etiology of human cancer.—*R. DeL. French.*

Comparative Washing Tests with Hard and Soft Waters. I. R. SMIT. Journal of Textile Institute, 23: A, 191, 1932. From Water Pollution Research Summary of Current Literature, 5: 9, 303, September 1932. Cotton and linen cloths were soiled with dirt and grease and were washed in water of zero, 5, and 13 degrees (German) hardness. Cloths were soiled and washed 25 times on a washing machine, being boiled with soap and soda and bleached with hypochlorite. Water of 13 degrees had a bad effect on color of cloths, zero water left them whiter, but water of 5 degrees was best. No important difference in decrease in tensile strengths of cloths was found.—*W. G. Carey.*

Oligodynamic Action of Metals on Bacteria. LA CAVA. Chimie et Industrie, 27: 868, 1932. Oligodynamic action is dependent on bactericidal power and colloidal solubility of metal in liquid; silver and copper, which have both these properties, are most effective. Bactericidal action of silver is due to passing of oxide to colloidal state and increases with amount of oxide in solution; if oxide eliminated from surface of metal, bactericidal action ceases. Bactericidal effect is due to penetration of colloidal silver into bacterial protoplasm.—*W. G. Carey.*

The Fundamental Chemistry of Water Supply: How to Read a Water Analysis. J. H. Coste. Water and Water Engineering, **34:** 406, 361–362, July 20, 1932 and 407, 408–412, August 20, 1932. Read before British Waterworks Association, June 22, 1932. Cycle of water in nature, including evaporation from oceans, precipitation, percolation, and run-off, is described; cause of more richly mineralized condition of large rivers than of rocky streams, or lakes is given. Base exchange action often occurs. Ordinarily hard waters, like those of Thames, Seine, and Mississippi, show supersaturation with calcium carbonate in respect to atmospheric equilibrium, but this decreases as sea is approached. Chloride of atmospheric origin is approximately 25 p.p.m. in British Isles; anything in excess is suspicious, unless satisfactorily explainable, as e.g. from infiltration of sea water, or from salt deposits. Water contains very small traces of phosphate; if amount present exceeds that just detectable by molybdate, sewage contamination is probable. It is preferable to express results of mineral analysis as positive and negative ions, and not as hypothetical salts.—*W. G. Carey.*

The Effect of Sodium Chlorate on Water Plants. M. Hessenland and F. Fromm. Chemiker Zeitung, **56:** 326, 1932. When duck weed and water weed were immersed in 0.25 percent sodium chlorate solution, many plants died; but all were not killed even with 1 percent solution. Higher concentrations were inadvisable, owing to poisonous nature of sodium chlorate. In one experiment, 1 percent solution was in contact with water weed for one day and then replaced by fresh tap water; after eight days, plants sank and turned brown; but recovered after three weeks.—*W. G. Carey.*

Thiosulphate as an Acidimetric Standard. J. Bicskei. Zeitschrift für analytische Chemie, **88:** 414–417, 1932. Sodium thiosulphate, chemically pure, dry, and powdered, is accurately weighed (0.2–0.5 gram) and dissolved in water; solution is treated with 2 cc. 4 percent potassium iodate, 0.3 gram potasium iodide, and 2 cc. starch; it is then diluted to from 50 to 100 cc. and titrated to blue end point with 0.1 normal acid to be standardised. For normal acid, ten times the thiosulphate, iodate, and iodide are prescribed. The reaction is $6\,HCl + KIO_3 + 5\,KI + 6\,Na_2S_2O_3 = 6\,KCl + 6\,NaI + 3H_2O + 3\,Na_2S_4O_6$.—*W. G. Carey.*

The Colorimetric Determination of Fluorine in Water with Ferric Thiocyanate. Margaret D. Foster. Jour. Amer. Chem. Soc., **54:** 11, 4464, November, 1932. Method is based on fact that complex ion formed in reaction between fluoride and ferric chloride does not give characteristic iron color with ammonium thiocyanate. Color given, therefore, by known quantity of iron will be less than if fluoride were absent. By determining colorimetrically quantity of iron reacting with ammonium thiocyanate, quantity withdrawn by fluoride is found by difference; its equivalent in fluoride is read from curve made by plotting effects of definite amounts of fluoride upon amount of iron used. *Procedure.* Suitable volume is evaporated to about 50 cc. and alkalinity neutralized. As little as 0.025 mg. of fluorine per 100 cc. of sample may be determined by using 5 cc. ferric chloride (0.1 gram of iron and 30 cc.

N hydrochloric acid in 1 liter) with 10 cc. ammonium thiocyanate (24 grams in 1 liter) in volume of 75 cc. If more than 0.4 mg. fluoride is present per 100 cc., smaller volumes and more iron must be used. Each amount of iron necessitates a separate curve. Acidity, temperature, and volume must be carefully controlled. Sulphate produces a similar, but lesser, effect upon the red color, to correct for which a similar curve may be constructed; 200 parts sulphate are, roughly, equivalent to 0.5 part fluoride. About 0.1 p.p.m. must be subtracted for each 500 p.p.m. chloride present, including hydrochloric acid used to neutralize. Less than 500 p.p.m. is negligible. Nitrate in usual concentrations is also negligible.—*Attmore E. Griffin.*

Proper Use of Surge Plungers in Developing Water Wells. ANON. Johnson Well Drillers Journal, October to November, 1932. Surge plunger, which combines simplicity, low cost, and efficiency, has no equal for development of wells in sand. Experience is required; for by improper use a well may be ruined. Stratum of hard clay over the sand or gravel aquifer is desired: over-lying sandy strata must not be broken down. Much depends on selection of proper slot size for the screen. Samples of strata must be carefully taken to guide judgment correctly. Surging should not be done when screen is full of sand.—*H. E. Babbitt.*

"The Best Water in The State." Where Is It? H. L. WHITE. Johnson Well Drillers Journal, October to November, 1932, p. 4. On what basis do people in so many widely scattered localities claim to have "the best water in the state." Is it based on laboratory analyses? Standard limitations of various characteristics and constituents are given. It is concluded that quality of water is based, by the layman, on taste. Eight ideal qualities of good water are listed.—*H. E. Babbitt.*

Forecasting Water Supply. G. D. CLYDE. Civil Engineering. 2: 10, 610, October, 1932. In forecasting run-off on some watersheds in Utah, snow cover is only factor that needs to be considered; but on others, watershed characteristics and spring and fall rains may have material effect. Another disturbing factor is premature melting of snow at low elevations. By measuring snow cover for a number of years and plotting against run-off, basic relation between snow cover and run-off can be determined. Measurement of precipitation at valley stations is not a good index of potential water supply. In attempt to forecast water supply, first prerequisite is measurement of snow on high watersheds. Depth measurements alone are not indicative of potential water supply. It is customary to sample a core of snow in a Mt. Rose snow sampler and weigh it. Field procedure for making observations is outlined. Detailed studies of relationship between snow cover and run-off have been made on Logan River watershed in Utah for past eight years. Three regular snow-survey courses have been established above an elev. of 8,000 ft. and a number of shorter courses at lower elevations. The graphs plotted indicate that there is a definite relation between snow cover and run-off. Results of state-wide snow surveys are published annually by U. S. Weather Bureau in March Climatological Data for Utah. As soon as sufficient records

are available, water-supply forecasts will be made annually for principal watersheds of state.—*H. E. Babbitt.*

Run-Off. Rational Run-Off Formulas. R. L. Gregory and C. E. Arnold. Trans. Am. Soc. Civil Engineers, 96: 1038, 1932. Exhaustive treatment, involving discussion of methods of estimating storm water run-off and suggestions for improvement. Contains mathematical analysis of factors involved and advocates new factors and formulas to be considered.—*H. E. Babbitt.*

Formulas for Rainfall Intensities of Long Duration. M. M. Bernard. Trans. Am. Soc. Civil Engineers, 96: 592, 1932. Rainfall intensity formulas, for any locality within the limits of the study, for frequencies between 5 and 100 years, and for rainfall duration periods of from 2 to 100 hours. Comparison between common type of formula developed for short-time duration, $i = a \div (t + b)$, in which i = intensity of rainfall, a and b are coefficients, and t is the duration of the storm, and hyperbolic type of formula, suitable for storms of long duration, $i = C \div t^n$, in which coefficient C and exponent n each depend on locality, shows that former gives lower intensities when its intended limit of 120 minutes is exceeded. Charts covering the eastern half of the U. S. are given, showing values of C and n for various localities.—*H. E. Babbitt.*

Flow of Ground Water as Applied to Drainage Wells. M. R. Lewis. Trans. Am. Soc. Civil Engineers, 96: 1194, 1932. Hydraulics of artesian, ordinary, and open-bottom wells are analyzed mathematically. Formulas for flow are derived which differ from formulas for water supply wells.—*H. E. Babbitt.*

NEW BOOKS

American Institute of Chemical Engineers, Transactions, 27, 1931. Published by D. Van Nostrand Company, Inc., New York City. 425 pages. More than one-third of the volume is devoted to a symposium of seven papers on the broad subject of stream pollution and the treatment of trade wastes. The authors included chemical, civil and sanitary engineers and governmental officials. The 155 pages devoted to this subject represent a pooling of knowledge secured from different sources and an analysis of the entire problem of waste disposal from the legal, economic and social angles as well as the technical. The initial source of the problem is traced to the congested industrial centers where until comparatively recently no laws were provided for regulating the disposal of wastes. It is shown how each stream or river has a definite and limited capacity for self purification and how this limit is affected by the dissolved oxygen present, natural reaeration, time, and the geography of the water shed. The experiences of the states of Connecticut, New Jersey and Pennsylvania in contending with this situation are outlined. A spirit of coöperation between the parties having conflicting interests in the solution of the problem is of paramount importance, since only in some cases can the

offender pay for the cost of treatment out of by-products recovered. An enumeration and detailed analysis of the powers granted federal and state governments is presented. The federal powers are indirect and relate chiefly to pollution affecting treaties, interstate commerce, or the public domains. The states' powers are direct, unlimited in scope and backed up by the enforcing powers of the police. The character of the wastes emanating from a number of different industries is discussed and specific methods suggested for the treatment of wastes from beet sugar and corn products factories, pulp and paper mills, packing houses, textile mills, tanneries, glue factories, canneries, dairies, and metal pickling mills. The balance of the volume is devoted to purely chemical engineering subjects, including a survey on chemical engineering education, a discussion of the relative merits of platinum versus vanadium pentoxide as catalysts for sulphuric acid manufacture, a symposium on heat technology, and a review of tests to determine the corrosion resisting properties of zirconium alloys.